STATE OWNERSHIP OF A DREDGE
ECONOMIC FEASIBILITY ANALYSIS

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Executive Summary

This report documents a study of the feasibility of the State of California purchasing and operating a dredge for beach nourishment purposes. The study investigated the economic and practical factors that would influence the decision. Specific tasks included the determination of the total anticipated dredging volume, an evaluation of the economic benefits of beach nourishment, the identification of appropriate dredges and their associated costs, and a review of additional dredging operational considerations.

The over-all conclusion is that beach nourishment has a positive cost to benefit ratio, but that the State is better served by contracting out beach nourishment projects as opposed to purchasing and operating a dredge on its own.

The following provides the specific the conclusions and recommendations from the study.

Conclusions

- There is sufficient nourishment potential and demand to evaluate a dredge purchase. However, the State must commit to a greatly increased level of long term funding for any dredge ownership scenario to be viable.
- On a regional basis, there is a nourishment demand of 3.5 to 5 million cubic yards of sand per year to meet published nourishment goals. Considering that several areas have been undernourished in recent years, the immediate need is for at least 15 to 18 million cubic yards.
- Annualized economic benefits derived from recreational uses total approximately $26 million and those from storm damage reduction reach approximately $24 million, for a combined total of $50 million for annualized economic benefits.
- Total annualized economic benefits equate to approximately $11 to $12 per cubic yard of sand used for nourishment when averaged over the state.
- The sources of sand available for additional beach replenishment work in California are predominately offshore.
- Offshore dredging requires a substantial investment due to the nature of the dredge required, specific certifications needed for dredges operating offshore, and specialized training and licensing of crew.
- A hopper dredge is much more flexible and can be applied to many more of the candidate beaches because hopper dredges are capable of dealing with longer distances between borrow site and receiver beach.
- Annual fixed cost of hopper dredge ownership ranges from $3.5 to $8.5 million dollars per year depending on size. This is independent of the amount dredged and is incurred whether the dredge works or not. To achieve a reasonable cost per cubic yard, this fixed cost must be spread over a large number of cubic yards.

- Larger dredges are more productive and more cost effective than smaller dredges.

- Contract dredging requires the payment of mobilization costs but alleviates the annual fixed cost commitment.

- By packaging work appropriately, the impact of contracted equipment mobilization can be minimized.

- Various beach and borrow source combinations are best dredged by various types and sizes of dredges. The purchase of a single dredge will optimize the costs of single type of project; however it may eliminate the possibility of completing other types of projects. Contracting allows for the most cost effective tools to be applied to each specific project.

- The average cost for dredging using a State-owned Dredge is $8.66/cubic yard based on the scenarios evaluated.

- The average cost for contracting beach nourishment dredging work is $6.00/cubic yard based on the SANDAG (SDBP1) contract history.

- To be competitive with contracted dredging prices would require a substantial annual scope of work (>3.5 million cubic yards per year) and a substantial financial commitment (>$20mil per year). This investment in a State-wide beach nourishment program is clearly justified from a cost-benefit point of view. (Benefits average $11 to $12/cubic yard, costs average $6.00 to $8.66/cubic yard.)

This analysis confirms the general belief that there is the potential to develop a regionally based State beach nourishment program that can readily demonstrate a positive cost/benefit comparison. This conclusion is independent of dredge ownership considerations, but requires a long-term financial commitment.

Recommendations Regarding Dredge Ownership vs. Contracting

After a detailed review of the relative cost of dredge ownership and consideration of the various issues associated with State ownership of a dredge, we recommend the State not pursue the purchase of a dredge for beach replenishment. The fundamental reasons for this recommendation are the expense, the complications of dredge ownership and the expectation that the private dredge industry could respond to the identified beach renourishment needs more efficiently than a state run dredge could.

The dredges required for the scope of beach replenishment identified (hopper dredges) are typically not resident in California. For this reason, there is often a significant mobilization expense for an individual beach replenishment project. In the case of the San Diego Regional Beach Project, that expense was more than $1 million dollars and in our judgment that was a relatively low number due to the fact that that dredge had just finished work in the Pacific Northwest (i.e. no Panama Canal mobilization required). Whether the mobilization is one million dollars or three million dollars, mobilization is a significant expense and spreading that mobilization over small scale quantities of beach work can make some projects cost prohibitive. However, owning a dredge is an enormous financial burden. In paying for industry dredge mobilizations, clients of dredging contractors are paying to get the right dredge when they need it and paying to release that dredge (and it's associated cost) as soon as the work is completed. With proper packaging of work and particularly if a steady volume of work can be developed, these mobilization costs can be managed and minimized as follows.

Recommendations for Improving the Cost Effectiveness of a Contracted Beach Program

This analysis and the associated cost models were developed to evaluate the feasibility of a State owned dredge. However, they also provide useful insight into the drivers of cost for contract dredging companies: the same issues of maximizing utilization and optimizing production and cost apply to industry dredges. As such, this analysis can be used to identify ways to maximize the cost effectiveness of a contracted beach renourishment program.

- Costs can be minimized in a contracted renourishment program by grouping beaches of similar scope (i.e. requiring similar dredge type) together in single contracts. This allows mobilization costs to be spread over larger quantities.

- A steady stream of funding and beach work will bring efficiencies because more frequent work will improve the likelihood of industry dredges being in the area. Should the volume of work be sufficient enough to justify the investment, the industry is capable of responding by building dredges. This is evidenced by the construction of two $50+ million dollar hopper dredges in the U.S. in the last six years.

1. Introduction

1.1. Study Purpose

The purpose of this study is to evaluate the economic and practical viability of the State of California purchasing and operating a dredge for use on beach replenishment projects.

1.2. Study Scope

The primary study scope included the following tasks.

Task 1: Identify, from existing studies, beaches in need of nourishment and potential sand sources which could be accessed by different types of dredges. Quantify the amount of sediment needed and the frequency of dredging/nourishment. (Section 2)

Task 2: Quantify the economic benefits of the identified nourishment projects. (Section 3)

Task 3: Examine the costs of ownership, operating and maintenance costs of various types of dredges including all ancillary shore and marine support equipment and vessels and compare these costs to the costs of contracting services out. (Section 4)

Task 4: Identify and tabulate potential borrow sites and distance to receiver beaches to determine the most feasible type of dredge to purchase. (Section 4)

Task 5: Prepare draft and final reports. (All Sections)

In addition to the primary study scope, a number of optional Tier 2 tasks were defined. These Tier 2 tasks addressed the following policy and economic issues in a qualitative manner and are discussed in Section 5.

Task 6: The dredge contracting climate and the resulting large uncertainty in engineer estimates in bid prices and how it can affect the future feasibility of nourishment projects.

Task 7: Types of state purchases and models for purchase of equipment, and compare ownership of existing operational and feasibility models of public entities, i.e. Port of Santa Cruz, US Army Corps of Engineers, or other states that own or operate dredges.

Task 8: Issues related to legal liability and self-insurance.

Task 9: The possibility of leasing or utilizing the dredge for other dredge activities during times when beach nourishment is not permitted.

Task 10: Potential constraints or advantages involved in using a State-owned dredge for US Army Corps projects. Examine if Corps dredges can be involved in the project and if the State dredge can be used in Corps projects.

Task 11: Financing mechanisms (dedicated taxes, bond issues, etc.) for cost-sharing between government agencies.

2. California Beach Replenishment Needs

2.1. Historical Background

There are several major economic and social drivers for beach replenishment projects in California.

- Before the 1980s, many tens of millions of cubic yards of sand from major harbor dredging and other coastal construction projects were placed on the beach. Throughout Southern California, previously narrow beaches were converted to wide, sandy beaches that became the norm. Maintenance dredging projects continue to provide sand for beach replenishment (e.g., Oceanside Harbor and Batiquitos Lagoon); however, the quantities are much smaller.

- Starting in the 1960s, the United States Army Corps of Engineers (Corps) and the State of California, along with several local jurisdictions, have replenished beaches to provide infrastructure protection. Examples of such projects are the Surfside-Sunset project (performed by the Corps as mitigation for impacts of the Anaheim jetties) and the recently authorized Imperial Beach project a Corps infrastructure storm damage reduction project),

- More recently, the State of California and other local jurisdictions performed beach replenishment projects that realized economic and environmental benefits from storm protection and recreational enhancements. The 2001 San Diego Association of Governments (SANDAG) beach nourishment served as a pilot project for this type of work in the State.

2.2. Beaches Excluded from the Study

As a part of identifying the beach nourishment needs in California that could reasonably be fulfilled by a State-owned dredge, the following classes of potential beach nourishment projects are excluded from the analysis:

- Ongoing harbor and other maintenance dredging projects, whether performed by the Corps or by local jurisdictions.

  These projects are excluded because a State-owned dredge, purchased and operated primarily for beach replenishment, would not be suitable for the majority of harbor maintenance projects due to the physical size of the equipment required, as described in Section 4.

- Authorized, or very likely to be authorized, Corps storm damage protection projects: Surfside-Sunset, other projects in feasibility study in Orange County, Encinitas/Solana Beach, and Imperial Beach.

  These projects are excluded because there is presently no mechanism for Corps-funded projects to be performed by a State-owned dredge. In principle, a State-owned dredge could compete for such projects. In practice, it is likely that the commercial dredging industry would lobby strongly against this. Even if the State were able to compete on equal terms with the commercial industry, these projects would not provide a guaranteed utilization for the State-owned dredge. While the State could provide a guaranteed utilization for the State-owned dredge by assuming the responsibility for funding of the Corps replenishment projects, this would not be a cost-effective use of State funds.

2.3. Specific Beaches vs. Regional Approach

This study uses a regional approach to the identification of beach replenishment needs, rather than an approach based around a specific list of currently proposed beach replenishment projects for the following reasons:

- The present list of proposed projects is based on previous nourishment quantities, not necessarily total nourishment potential.

  The practice of large-scale beach replenishment in California is at a relatively early stage, and in many cases the sand quantities have been relatively small compared to the overall sediment budget deficit. The quantities of sand have been determined by funding availability and caution on the part of project sponsors and regulatory agencies. This means that the overall need for beach replenishment may not be captured by any current list of proposed projects and quantities.

- The present annual nourishment quantity from identified priority projects is insufficient to fully utilize a reasonably-sized dredge.

  The quantity of sand identified from a list of proposed projects (Appendix A) would result in a very low dredge utilization situation. By using a regional approach, we are able to present the cost implications of the full range of potential annual nourishment quantities – including relatively high dredge utilization scenarios.

2.4. Regional Beach Replenishment Needs

Table 2.1 provides a description of identified beach replenishment needs, listed geographically (north to south). Much of the table is based on sediment budgets and on previous studies of sediment deficit by littoral cell – rather than on specific project descriptions. As such, the values shown here do not necessarily match specific proposed replenishment projects (including the listing in Table A., Appendix A). The exceptions are as follows:

- Ocean Beach, San Francisco Littoral Cell. This is an erosional hotspot in a heavily modified littoral cell.

- Goleta and Isla Vista, Santa Barbara Littoral Cell. Goleta Beach has been very heavily studied in recent years. The sediment deficit in the area is small compared to the overall littoral transport in the area. As such, this table uses the sediment deficit identified for the most critical stretch of beach – rather than an overall sediment deficit for the littoral cell. The sediment deficit for the adjacent Isla Vista beach is based on a similar erosion rate.

The target reaches and specific beaches for beach replenishment are shown in Figure 2.1. This figure also shows potential borrow sources (which affect the replenishment costs). For those reaches where a more detailed breakdown of the beaches within a reach has been used in the economic analysis (Sections 3), the figure lists the specific beaches considered.

TABLE 2.1: CALIFORNIA REGIONAL BEACH REPLENISHMENT NEEDS

Littoral Cell	Target Reaches	Target Reach Length (ft)	Annual Sediment Deficit (cy)	Replenish-ment Interval (years)	Replenish-ment Quantity (cy)	Annual Replenish-ment Qty (cy) [1]	Beach Width Increase (ft) [2]	Erosion Rate (ft/year) [2]
San Francisco	Ocean Beach	3,000	500,000	2	1,150,000	575,000	360	180
Santa Barbara	Isla Vista	9,000	100,000	2	230,000	115,000	30	15
	Goleta	2,200	50,000	2	120,000	60,000	60	30
	Carpinteria	1,300	80,000	5	460,000	90,000	175	35
	North Ventura	15,000	300,000	2	690,000	345,000	25	12
	Ventura River to Ventura Harbor	18,000	200,000	5	1,150,000	230,000	37.5	7.5
Santa Monica	Point Dume to Topanga Canyon	60,000	90,000	10	1,050,000	105,000	10	1
	Topanga Canyon to Marina Del Rey	45,000	200,000	10	1,150,000	230,000	30	3
	Marina Del Rey to Redondo Canyon	60,000	260,000	10	3,900,000	300,000	30	3
Oceanside	Oceanside to Torrey Pines	100,000	1,530,000	3	5,300,000	1,765,000	30	2.5
Mission Bay	Mission Beach and Ocean Beach	20,000	300,000	3	1,050,000	350,000	30	2.5
Silver Strand	Silver Strand	30,000	450,000	3	1,660,000	535,000	30	2.5
TOTALS		363,500 (ft)	4,060,000 (cy)		17,910,000	4,700,000		

1. The total quantity is much larger than current State- or locally-funded replenishment. A significant increase in funding for beach replenishment would be needed to address the needs identified here.

2. The average increase in beach width immediately after replenishment, and the average erosion rate, over the specified target reach. In many cases, the constructed project(s) would cover a shorter length of beach and would create a much wider beach in the immediately nourished area.

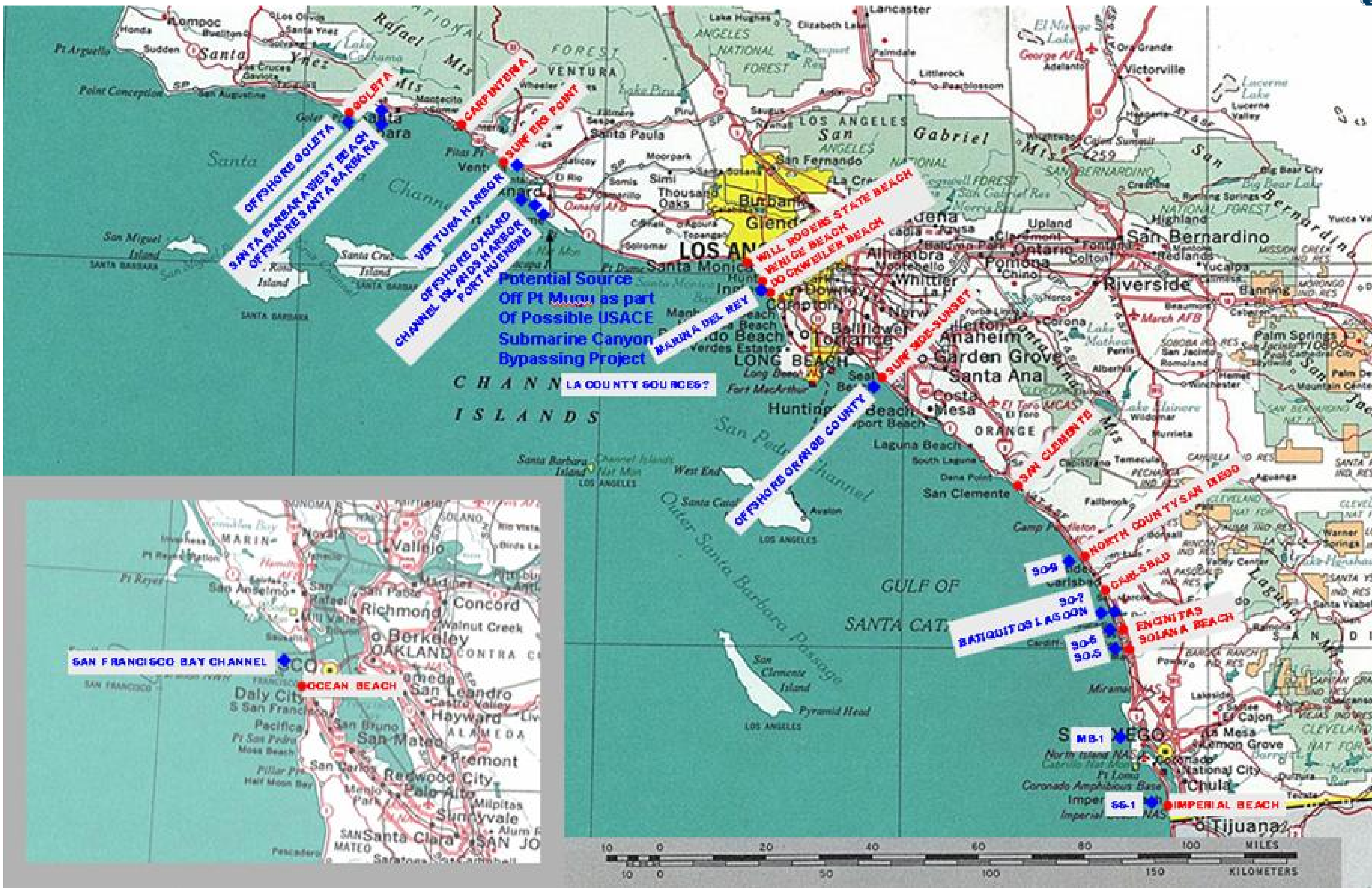


FIGURE 2.1 REGIONAL BEACH REPLENISHMENT PROJECTS AND POTENTIAL BORROW SOURCES

For the longer, regional reaches, the specified increase in beach width resulting from beach replenishment is rather small. This should be taken as the average increase over the entire reach. Actual constructed beach replenishment projects would focus sand placement on smaller reaches, either at the upcoast end of the littoral cell (feeder beaches) or in areas where the recreational or other value of the beach is particularly high.

The values in Table 2.1 have been obtained as follows (note the replenishment quantities typically include a 15 percent overfill factor).

Ocean Beach, San Francisco Littoral Cell

The proposed replenishment project is one of the alternatives proposed in the study by Moffatt & Nichol (2007a). This study was intended to provide the basis for a Corps storm damage reduction study under Section 933 (which provides for beneficial reuse of dredged material based on its marginal cost). As such, the project has not been optimized: this is a plausible rather than a definite beach replenishment quantity.

Isla Vista and Goleta Beaches, Santa Barbara Littoral Cell

The proposed replenishment project for Goleta Beach is based on the annual sediment deficit obtained by Moffatt & Nichol (2002, 2006) and Chambers Group (2007). The current estimate of the sediment deficit at the park is between 30,000 and 60,000 cubic yards per year; the nourishment project for Goleta is based on the “nourishment with fully reveted beach” alternative analyzed by Chambers Group (2007). The construction would cover about 2,200 feet of the beach.

At Isla Vista, it is assumed that the density of beach replenishment would be approximately one-half of that within the Goleta project. The rationale is that, at Goleta, the beach replenishment project only covers about one-half of the littoral sub-cell (from Goleta Point to approximately the easternmost range of the mouth of Goleta Slough). Thus, the effective beach replenishment density at Goleta is approximately one-half that calculated directly from the reach length and replenishment quantity.

The Isla Vista replenishment density is selected to match the effective density at Goleta. While larger projects have been proposed for Isla Vista, the very strong littoral transport from Isla Vista to Goleta and further east means that additional sand would tend to nourish the beaches further downcoast – leading to a double-counting in the proposed beach replenishment quantities.

Carpinteria Beaches, Santa Barbara Cell

The annual sediment deficit for the immediate vicinity of Carpinteria is based on the sediment budget and transport analysis by Noble Consultants (1989), and is consistent with the replenishment alternatives presented by the US Army Corps of Engineers (2003). The replenishment period and increases in beach width are consistent with the erosion rates and alternatives proposed by the Corps.

North Ventura Beaches, Santa Barbara Cell

This region represents the stretch of coastline from Rincon Point to the mouth of the Ventura River. This reach has been subject to encroachment by highway construction, and it appears that sand is being transported offshore in response to changes to the shoreline (Noble Consultants, 1989). Based on the sediment budget by Noble, it appears that up to 140,000 cubic yards per year is being lost offshore. However, erosion in this area is limited by seawalls and revetments throughout the reach.

The proposed replenishment in this area is selected on the general considerations that the majority of nourishment would occur at beach parks; that, based on current conditions, a two-year beach replenishment cycle would probably be necessary; and that a typical replenishment density would be 1.5 cubic yards per square foot of beach. The relatively large replenishment quantity, compared to other beaches in the Ventura area, appears justified based on heavy public use of the area.

As previously mentioned, the actual constructed replenishment projects would not cover the full length of the specified reach. Rather, a series of shorter projects would be constructed with a wider template. The relatively narrow beach replenishment listed here is an average over the reach length, representing the full length of the public beaches of particular recreational value.

Ventura River to Ventura Harbor, Santa Barbara Cell

The annual sediment deficit in this area is based on the sediment budgets by Noble Consultants (1989) and Patsch and Griggs (2007). Given the sediment deficit, the erosion rate and proposed replenishment cycle are based on a standard beach replenishment density of 1.5 cubic yards per square foot of beach.

Santa Monica Littoral Cell

The Santa Monica littoral cell and its beaches have not been studied for the purpose of beach replenishment to the same extent as other littoral cells in southern California. In the most heavily used, southern part of the littoral cell, erosion has been relatively slow, largely due to historic major nourishment projects associated with Marina del Rey harbor construction and the Hyperion Sewage Treatment Facility. Existing groins and breakwaters have assisted in retaining beach sand in the area. However, the beaches have narrowed to the extent that attention is being drawn to the need for replenishment.

Between 1939 and 1969, sand placement on the beach or nearshore added an average 550,000 cubic yards per year of sand to this littoral cell, causing the beaches to widen significantly, particularly to the south (Patsch and Griggs, 2007). Little sediment has been added to the littoral cell since the 1970s. Consequently, this is assumed the sand deficit over the entire littoral cell.

This study allocates the sediment to the littoral cell based on reach length and the intensity of beach usage. North of Topanga Canyon is a relatively unpopulated area with beaches that have never been particularly wide. As a result, the study allocates a relatively small quantity of sand to this stretch of beach compared to areas to the south and it is assumed it would help to feed the southern part of the littoral cell over time. Even this reduced quantity of beach replenishment may be politically unpopular with residents that possess fairly exclusive small private beaches and may cause potential environmental impacts to existing sensitive reef habitat areas along this reach of coast. Additionally, the nearby presence of Mugu Canyon, which traps approximately one million cubic yards per year of sand, makes sand bypassing an attractive option for nourishing the northern part of the beach.

A ten-year nourishment cycle is selected, based on the beach retention structures (groins and breakwaters) which tend to slow beach loss in the area. The average increase in beach width over the reach, and the erosion rate, are based on the assumed sediment deficit and the standard 1.5 cubic yards per square foot of beach.

Oceanside, Mission Bay, and Silver Strand Littoral Cells

The proposed beach replenishment in the San Diego region is based on the expressed long-term wish to build out the beaches in the area (SANDAG 1993), rather than simply to keep the beaches from eroding further. The recent (2001) beach replenishment project represented a first step in the long-term strategy to build out the beaches. Monitoring results for this project (Coastal Frontiers, 2006) showed that the performance of beach replenishment along the San Diego County coastline was variable: some areas of beach eroded back to (or beyond) their pre-nourishment profiles within a year or two, while others remain wide five and six years on.

The proposed overall replenishment rate is based on the assumption that the beach throughout the San Diego County shoreline is to be built out by 150 feet over 20 years. The reaches included are essentially the entire Oceanside littoral cell, from the south end of Camp Pendleton to the beaches at Torrey Pines (excluding the rocky areas by Scripps); Mission and Ocean Beach; and the Silver Strand shoreline. The Coronado shoreline is excluded because this area of beach is accretional, while much of the shoreline at the City of Imperial Beach is excluded because of the recently-authorized Corps storm damage reduction project. The Corps project will add a further 100,000 cubic yards annually to the region.

In the Oceanside littoral cell, 44,000 cubic yards annually of sediment are currently sourced from bluff erosion (Patsch and Griggs, 2007). It is assumed that this source of sediment will be lost from the littoral cell if a wide beach is obtained. Consequently, this quantity is added to the assumed sediment deficit for that cell.

The increase in beach width – averaged over the entire reach – is based on the specified sediment placement and the standard 1.5 cubic yards per square foot of beach, which has been confirmed by the recent SANDAG beach nourishment.

The annualized placement quantity is several times larger than the annualized placement quantity for the 2001 SANDAG project. This large quantity is based on an assumed long-term program to build out the beaches – rather than a simple repetition of the previous project, which represent a compromise between the need for beach replenishment, available funds, and environmental considerations.

3. Economic Analysis

3.1. Introduction

Measuring the economic value of nourishment is more challenging than measuring the value of market goods that are bought and sold. The economic value of a market good is the sum of what individuals are willing to pay for it in the marketplace. In the State of California, beach access above the mean high-tide line is open to all and beaches are free, though one must sometimes pay for parking. Consequently, there are no explicit prices that can be used to compute the value individuals receive from visiting a beach or the total economic benefit (consumer surplus) that accrues to all visitors to that beach.

3.2. Recreational Benefits

Economists have developed several techniques for estimating the economic value of a day at the beach. The two most common techniques used are the travel cost method (TCM), which uses the cost of travel to the beach as an implicit price of admission, and the contingent valuation method (CVM), which employs survey data questioning how much people are willing to pay for a day at the beach. Of course, different people have different valuations and travel costs, but a sound analysis will estimate the average value of a day at the beach for a typical visitor, usually in high season. A number of studies of specific beaches in California have been conducted.

Estimates of beach value per day for beaches with a high recreational value (e.g., Huntington Beach) range from $10 to $30. The most comprehensive study currently underway, the Southern California Beach Valuation Project (NOAA 2007) examines a panel of day-trippers in Southern California and uses a Random Utility Model (RUM) to estimate the value of a beach day. The advantage of RUM's is that these models specifically account for the fact that one beach may be a close substitute for another beach - hence if one beach disappears or erodes, people will go to another beach. Unfortunately, the project focused on Southern California beach goers and thus may underestimate the value of these beaches somewhat.

To be conservative, this analysis applies a maximum value of $14 per day for a beach day. As a practical matter, most beaches in the study are valued at $10 or less since none are perfect. More details on the assumptions being used for the economic analyses are provided in Appendix B.

3.3. Non-recreational Benefits

In addition to recreational benefits, beaches provide potential benefits to coastal property and infrastructure which may be significant. Adding sand to beaches and other coastal sites decreases the probability of public and private property being damaged in severe winter storms. In the event of a storm, beaches act as a buffer, limiting the encroachment of the ocean and ocean waves on inland property. These benefits accrue to both public and private property. However, this study only considers public benefits because the State only allows benefits to public property and infrastructure to be considered when using State tax dollars.

Data on storm damage prevention is limited. The US Army Corps of Engineers has prepared specific studies for nourishment projects at specific sites. However, storm damage prevention benefits are very site-specific. In this study, the estimates are generally limited to loss of public land due to erosion. Incorporating other storm damage prevention benefits, such as the increased benefit of preserving roads and municipal utilities would yield a higher result, though the value of lost public land is likely to be the most significant factor overall. Including the loss of private property also would yield substantially higher benefits.

The one exception was Ocean Beach in San Francisco. The primary benefit of a replenishment project here is storm damage prevention, since the beach abuts a highway and significant infrastructure associated with a water treatment plant. The recreational value of this beach is limited in comparison to other beaches due to the cold weather in San Francisco, the cold water, and typically hazardous swimming and surfing conditions. Nevertheless, the beach is quite popular with surfers and becoming more so. The beach is also a favorite spot for people walking, often with dogs.

Some of the sites included in this study contain reaches with seawalls. In this case, storm damage should be limited, but beach replenishment could still potentially provide benefits in the case of severe storms.

Protecting sandy beaches also can potentially preserve adjacent wetlands and salt marshes by mitigating the effects of storms. A number of endangered species benefit from this mitigation, including the salt marsh bird's beak (endangered plant species), the western snowy plover (endangered bird species), the California brown pelican (endangered bird species), the light footed clapper rail (endangered), Belding's savannah sparrow (endangered), and the Pacific pocket mouse (endangered). This study does not attempt to capture these environmental benefits in economic terms.

3.4. Data Sources

Data and information for the benefits analysis portion of this study came from a variety of existing sources, including as yet unpublished data collected by the study team. It is anticipated the unpublished information will be published in due course, but possibly after the current study is complete.

- *Ocean Beach, San Francisco County*: unpublished data collected by Dr. King and his research assistants, and unpublished work developed in draft form by Moffatt & Nichol for the City and County of San Francisco.

- *Santa Barbara Littoral Cell*: data prepared in support of the CSBAT analysis (US Army Corps of Engineers 2006).

- *Santa Monica Littoral Cell*: attendance data from the County of Los Angeles, and beach width from an unpublished data set developed by the UCLA Department of Geography.

- *Oceanside, Mission Bay, and Silver Strand Littoral Cells*: Most of the sites in San Diego County were also SANDAG sites, and data and analysis was taken directly from the recent feasibility study for ongoing beach replenishment (SANDAG and Moffatt & Nichol, 2007). Two beaches in San Diego County, Ocean Beach (not to be confused with Ocean Beach in San Francisco) and Silver Strand, were not included in the SANDAG study, and unpublished data together with official attendance data were used for these sites.

Recreational benefits for California beaches are very site-specific, since they depend on a range of amenities including local weather, beach condition, and crowding (see Appendix B). Consequently, this section structures the analysis of benefits around specific beaches. The results are summed to give the total benefits for each littoral cell and reach as listed in Table 2.1.

As described in the context of the reach lengths and beach characteristics in Table 2.1, the regional approach considers an average increase in beach width and an average erosion rate, often over a long reach such as the majority of the Santa Monica littoral cell. Actual constructed beach replenishment projects would focus sand placement on smaller reaches, either at the upcoast end of the littoral cell (feeder beaches) or in areas where the recreational or other value of the beach is particularly high. The total sand quantities, resulting increase in beach area and subsequent loss of beach area through erosion in this section match those in Section 2.4.

3.5. Results

The results for each littoral cell are presented in Table 3.1. Recreational and storm damage reduction benefits are separately annualized (in 2007 dollars) and summed. The storm damage benefits are conservative and likely underestimate the total benefit: these benefits look only at benefits to public property and infrastructure. The annualized benefits per cubic yard divides the total annualized benefits by the annualized beach fill. This estimate is useful when examining dredge projects since average dredge costs are often measured in costs per cubic yard.

Benefits vary considerably by region and by site. The northern sites have the highest benefits per cubic yard. This is based on estimated storm damage reduction benefits. Ocean Beach in San Francisco and Carpinteria Beach in southern California are sites with relatively high benefits. The average benefit when considered over the entire data set is slightly less than $8 per cubic yard.

Results for the Santa Monica littoral cell vary considerably. The northern reach, encompassing Malibu's beaches has very high benefits, largely a result of narrow beaches and high property prices. The difference in the value of nourishment is largely a function of beach width: wider beaches benefit less from an incremental addition of beach width. The beaches in Los Angeles also benefit from the fact that they are enormously popular, drawing tens of millions of people per year.

Overall, the calculated benefits per cubic yard for San Diego County – Oceanside, Mission Bay, and Silver Strand littoral cells – are surprisingly low. This is largely due to the fact that much of the fill goes to Silver Strand, which has relatively low recreational values.

The overall calculated benefits per cubic yard are between $11 and $12 per cubic yard: the upper end of this range applies if Silver Strand is eliminated.

TABLE 3.1: ANNUALIZED BENEFITS OF BEACH REPLENISHMENT BASED ON TOTAL IDENTIFIED NEED

Littoral Cell / Reach / Beach	Annualized Recreation Benefits (2007$)	Annualized Storm Damage Benefits (2007$)	Annualized Total Benefits (2007$)	Annual Beach Replenishment (cy)	Benefits per Cubic Yard (2007$/cy)
San Francisco, Ocean Beach	$ 610,000	$ 8,070,000	$ 8,680,000	575,000	$15.10
Santa Barbara Littoral Cell					
Isla Vista	$210,000	$340,000	$550,000	115,000	$4.80
Goleta	$380,000	$170,000	$550,000	60,000	$9.20
Carpinteria	$1,140,000	$50,000	$1,190,000	90,000	$12.90
North Ventura					
La Conchita	$20,000				
Oil Piers	$10,000				
Rincon Parkway	$540,000				
Hobson Beach	$200,000				
Emma Wood	$150,000				
Total North Ventura	$910,000	$530,000	$1,450,000	345,000	$4.20
Ventura River to Ventura Harbor					
San Buenaventura	$110,000				
Pierpont	$50,000				
Total Ventura River to Ventura Harbor	$160,000	$370,000	$520,000	230,000	$2.30

State Ownership of a Dredge Economic Feasibility Study

TABLE 3.1: ANNUALIZED BENEFITS OF BEACH REPLENISHMENT *(CONT.)*

Littoral Cell / Reach / Beach	Annualized Recreation Benefits (2007$)	Annualized Storm Damage Benefits (2007$)	Annualized Total Benefits (2007$)	Annual Beach Replenishment (cy)	Benefits per Cubic Yard (2007$/cy)
Santa Monica Littoral Cell					
Point Dume to Topanga Canyon					
Escondido	$90,000				
Malibu	$950,000				
Las Tunas	$780,000				
Topanga	$290,000				
Total Point Dume to Topanga Canyon	$2,110,000	$1,875,000	$3,985,000	105,000	$38.00
Topanga Canyon to Marina Del Rey					
Will Rogers State Beach	$570,000				
Santa Monica	$970,000				
Venice Beach	$1,240,000				
Total Topanga Canyon to Marina Del Rey	$2,780,000	$840,000	$3,620,000	230,000	$15.70
Marina Del Rey to Redondo Canyon					
Dockweiler	$610,000				
El Segundo	$170,000				
Manhattan	$1,130,000				
Dan Blocker	$580,000				
Hermosa	$540,000				
Redondo	$790,000				
Total Marina Del Rey to Redondo Canyon	$3,820,000	$1,500,000	$5,320,000	300,000	$17.70

TABLE 3.1: ANNUALIZED BENEFITS OF BEACH REPLENISHMENT *(CONT.)*

Littoral Cell / Reach / Beach	Annualized Recreation Benefits (2007$)	Annualized Storm Damage Benefits (2007$)	Annualized Total Benefits (2007$)	Annual Beach Replenishment (cy)	Benefits per Cubic Yard (2007$/cy)
Oceanside Littoral Cell					
Oceanside to Torrey Pines					
Oceanside	$1,030,000				
North Carlsbad	$840,000				
South Carlsbad	$1,180,000				
Batiquitos	$410,000				
Leucadia	$1,180,000				
Moonlight Beach	$890,000				
Cardiff Beach	$1,160,000				
Fletcher Cove	$140,000				
Del Mar	$2,240,000				
Torrey Pines	$810,000				
Total Oceanside to Torrey Pines	$9,880,000	$9,170,000	$19,050,000	1,765,000	$10.80
Mission Bay Littoral Cell					
Mission Beach Area					
Mission Beach	$1,540,000				
Ocean Beach	$1,430,000				
Total Mission Beach Area	$2,970,000	$410,000	$3,380,000	350,000	$9.70
Silver Strand Shoreline	$550,000	$560,000	$1,110,000	535,000	$2.10

4. Dredge Purchase Analysis

4.1. Types of Dredges Considered

Direct placement of dredge material on a beach is most typically performed by cutter suction or hopper dredges. There are some situations where mechanical dredges are used to place dredged material in nearshore berms, such as the recent USACE dredging in Marina Del Rey with nearshore placement off Dockweiler Beach. However there are physical limitations to this type of dredging that make it not practical for large-scale, deep water beach nourishment projects. Therefore, this analysis only considers the two major dredge types that are capable of direct on-beach placement, cutter suction and hopper dredges. A brief description of each of these types is shown below.

4.1.1. Cutter Suction (Pipeline) Dredge

A cutter suction dredge is a hydraulic dredge that uses a rotating cutting apparatus around the intake of a suction pipe, called a cutterhead, to break up or loosen seabed material, as shown in the figure and pictures below. Large centrifugal pump(s) hydraulically transport the material mixed in a slurry of seawater from the seabed at the borrow site through a discharge pipeline directly to the beach receiver site. While cutter suction dredges are operating, the delivery of material to the beach is continuous, generally providing for higher production rates than hopper or mechanical dredges which have separate loading, transport and discharge steps to their operation. Cutter suction dredges can operate in very shallow water as they don't load material into a hull and therefore don't need significant depth for draft clearance. The greatest limitation to the use of cutter suction dredges is the requirement for the borrow site and receiver site to be within direct pumping distance of one another. This maximum economical distance varies with the size and horsepower of the dredge as well as the grain size of the material being pumped but is generally between 3 and 6 miles without booster pumps. Another limitation to cutter suction dredges is that they have a lower tolerance for high wave climates due to the fact that they dig from a fixed position with a firm connection to the seabed. They are also a more expensive tool to mobilize from great distances due to the amount of ancillary equipment required.

Cutter suction dredges are rated on several different factors, including the diameter of the discharge pipe (which ranges from 6" to 36" inches), their cutter horsepower (up to 8,000hp worldwide) and total installed horsepower (up to 38,000hp worldwide). One important differentiator with hydraulic dredges is the difference between inland and offshore dredges. To be allowed to operate offshore, a dredge (or any commercial vessel longer than 24m) needs to have a load line certificate issued by the American Bureau of Shipping (ABS). Generally speaking, only larger dredges are load line certified to operate offshore.

FIGURE 4.1 ILLUSTRATIONS OF CUTTER SUCTION HYDRAULIC DREDGES


Cutter Suction Hydraulic Dredge (Oilfield Publications Limited, n.d.)


Close-Up of Cutter


Example of Cutter Suction Dredge in offshore beach renourishment (GLDDS "Illinois")


Manson Construction H.R. Morris

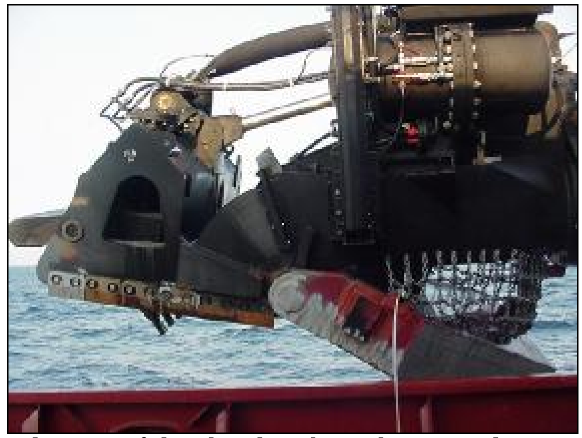
4.1.2. Hopper Dredge

Hopper dredges are self-propelled vessels that have the shape of a conventional ship hull and are equipped with either single or twin trailing suction pipes, as shown in the figures and pictures below. Material is agitated by teeth and high pressure jets on a "draghead" that is on the end of the trailing suction pipe(s). The vessel has a large void within the hull known as the "hopper". A hopper dredge operates much like a floating vacuum cleaner in that the vessel is loaded with material by dragging the draghead(s) across the seabed and sucking a slurry of dredged material and seawater up the suction pipes. This slurry is discharged into the hopper and the dredged material settles out in the hopper while the transport water is returned via an overflow standpipe. Once loaded, the suction pipes are raised and stored on the deck and the dredge sails to the pump out location. At the discharge area the dredge connects to a waiting pipeline, the material is re-slurried with seawater and pumped out of the hopper, through the pipeline and onto the beach.

Hopper dredges are often used in open ocean applications as they work better in sea and swell than other types of dredges. They are also often used when the distance between dig site and discharge site is longer than a cutter suction dredge could pump. They need deep water to accommodate their loaded draft. Because they dig underway and are not fixed to the bottom, they also need maneuvering room, which is normally not an issue in offshore borrow sites but can be for inlet navigation channels (i.e. a hopper dredge could be too large to turn around in many small navigation inlet channels). Hopper dredges do not dig very firm material well and their production can be negatively impacted by fine grain material that does not settle well in the hopper.

FIGURE 4.2 ILLUSTRATIONS OF HOPPER DREDGES


Typical Hopper Dredge Loading (Oilfield Publications Limited, n.d.)


Side view of draghead with teeth, jets and turtle deflector.


Hopper dredge *Sugar Island* pumping out offshore San Diego


Hopper dredge *Sugar Island* pumping out offshore of San Diego

4.2. Cost of Dredge Purchase

The initial cost of a dredge depends on the type of dredge purchased, its size, and its capability, as well its age and condition. M&N is familiar with the construction and resale of large dredges that has occurred over the last ten years. There is not a significant U.S. market for dredges suitable for offshore beach replenishment work: such dredges have not been built or resold with any regularity in recent years. For the purposes of this study, M&N chose to use the CIRIA's "Cost Standards for Dredging Equipment 2005" (with 2006 indexes that were published in February of this year)[1] to evaluate the cost of six different dredges: a small, medium, and large size of each of the two dredge types considered. These cost standards provide a consistent way to evaluate the cost of a new build dredge based on vessel type, class, size, and power inputs. They are based on construction in Europe with conversion from Euro to Dollar based using 1.47 dollars per Euro. The costs for recent U.S. new build dredges were used as a check on the resulting values: the results validated the cost formulas in the CIRIA guidance.

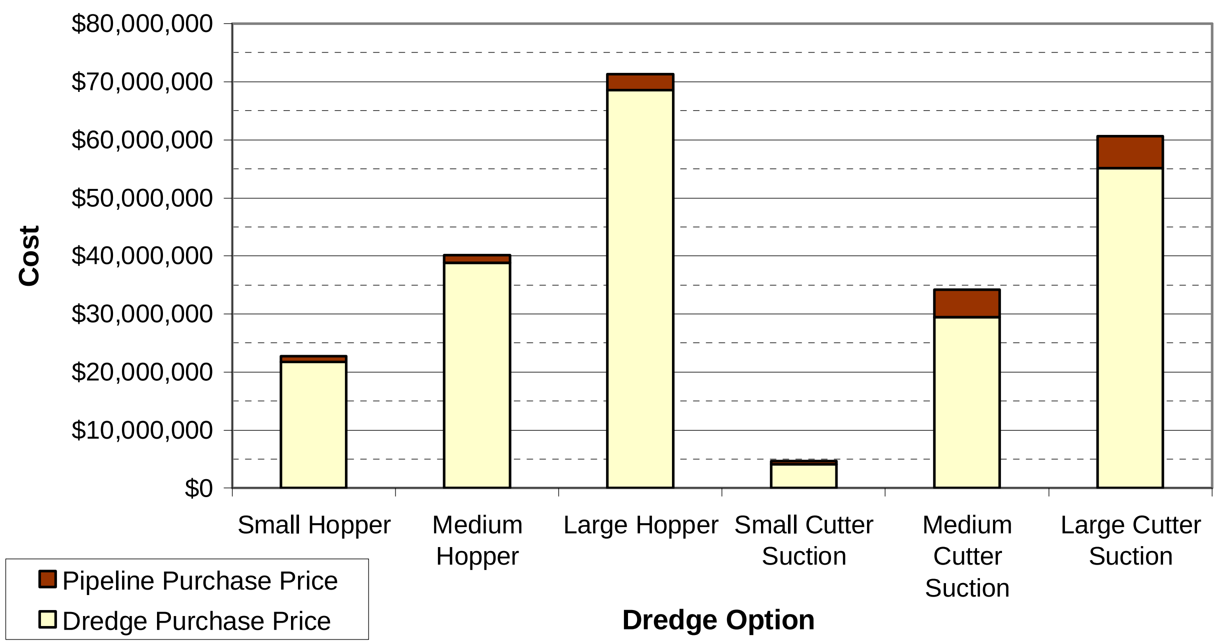
New build costs of the six dredges considered are shown in Table 4.1 and Figure 4.3.

[1] http://www.ciria.org/acatalog/C655.html

TABLE 4.1: DREDGE PURCHASE FEASIBILITY - INITIAL COSTS

		Small Hopper	Medium Hopper	Large Hopper	Small Cutter Suction	Medium Cutter Suction	Large Cutter Suction
		split hull	split hull		non class	non class	under class
Similar to a new build of :		GLDD Northerly Island	GLDD Sugar Island	Stuyve-sant	Ross Island's No. 10	Manson's H.R. Morris	GLDD Texas
Dredge Characteristics							
Discharge Diameter	in	20	24	36	16	30	30
Dragarm Diameter	in	20	27	36	N/A	N/A	N/A
No. Arms	#	2	2	2	N/A	N/A	N/A
Hopper Size	cy	2,067	3,600	10,072	N/A	N/A	N/A
Installed Power	hp	4,010	8,435	14,684	N/A	N/A	N/A
Cutter Power	hp	N/A	N/A	N/A	201	1,500	3,000
Total Cutter Power (cutter + pumps)	hp	N/A	N/A	N/A	1,601	7,500	15,000
New Build Value (07') (using CIRIA formulas)	$	21,775,108	38,857,174	68,504,769	4,116,755	29,430,419	55,141,652
Pipeline Costs (see Table 4.2)	$	949,727	1,287,980	2,749,087	612,488	4,777,444	5,410,373

FIGURE 4.3 DREDGE PURCHASE FEASIBILITY - INITIAL COSTS



4.2.1. New vs. Used

Using an assumption of a new build dredge provides for a balanced comparison of dredge types and sizes in regard to capital cost, service life, production capability and resulting unit price of delivered sand. Older dredges would be less expensive in initial purchase, but would generally be less capable, have higher maintenance costs and a shorter usable life. Moreover, it is unlikely the state would be able to find a contractor willing to sell a vessel of the nature required in this study. The field of dredges that would suit the needs of the state is quite limited as discussed below under section 4.2.2.

4.2.2. Certifications Required

There are several key restrictions the State will need to take into account when considering the purchase of a dredge. They are:

- A vessel dredging in the navigable waters of the U.S. has to be a U.S. built, U.S. flagged, and U.S. controlled dredge. These requirements stem from the Foreign Dredge Act of 1906, The Shipping Act of 1916 and the Merchant Marine Act of 1920 (a.k.a. the "Jones Act"). These requirements limit the field of existing dredges the state could consider purchasing. Additionally, any new build dredge to be built in the U.S., a significant factor in the cost of construction. These costs of U.S. construction are included in the estimates of cost above.

- Coast Guard regulations require any commercial vessel longer than 24m to have a load line certificate to operate offshore. Certifications in the U.S. are made by the American Bureau of Shipping (ABS). In general, this requires the dredge to be built to certain stability and navigational safety standards. These regulations also require routine inspection to maintain certification. Since all of the borrow sites under consideration are offshore, we limited our consideration to ABS load lined (or "classed") dredges. This greatly reduces the field of existing dredges that would work for the State and also has a substantial impact on the cost of new-build construction. These additional costs for a "classed" vessel are included in the estimates above.

- In California, the operation of large diesel engines onboard dredges has been regulated by both local air districts and the state, through the Air Resources Board. While the exact requirements for the unrestricted operation of a state dredge are beyond the scope of this study, it is clear this is an area that will require careful consideration before a dredge purchase decision is made. Additionally, if a used dredge were purchased, air quality permitting of an existing dredge could be problematic due to the emission rate of older in place engines as compared to the lower emitting engines that would be installed on a new build dredge.

4.3. Cost of Dredge Operation

The costs for operating the six dredges considered for purchase are evaluated below. These costs are structured as a dredging contractor would and include both fixed and variable costs. They are based on a combination of the CIRIA cost standards (for depreciation, interest & maintenance expense) and the industry experience of M&N team members (for insurance, fuel, labor, rentals & pipe wear). Mobilization costs are evaluated separately in the dredging scenarios section as is production at individual borrow / receiver beach combinations.

4.3.1. Variable vs. Fixed Cost of Dredge Ownership & Operation

Fixed Costs are costs that are incurred whether the dredge operates or not and are estimated on an annual basis. They include:

- Depreciation & Interest: Much like a car payment, the depreciation and interest is an annual payment on the capital cost of the dredge. Depreciation and interest payments for various type and size dredges in this analysis were based on the CIRIA cost standards. The service life assumed is 18 years, with a 7% interest rate and 10% assumed salvage value.

- Insurance: The cost of insurances such as hull, liability, marine pollution etc. Insurance costs in this analysis are based on an estimated annual payment which is an assumed percentage of the dredge value (0.5%). These costs do not include worker insurances such as workers comp, USL&H and Jones Act coverage, which are built into the labor rate estimates.

- Fixed Labor & Overhead: Dredges of the size and type considered in this study require a select number of crew to be full time with the dredge whether it is working or not. This select crew maintains it and must be familiar enough with its operation to instruct and supervise the more transient crew that will be hired and laid-off as projects are executed. Fixed labor and overhead costs in this analysis are based on an estimated annual overhead budget.

- Fixed Maintenance: Some maintenance expenses are independent of whether or not the dredge operates, such as dry-docking required to maintain class certification, and anti-corrosion maintenance such as paint etc. Fixed maintenance expenses in this study are based on the CIRIA cost standards.

Variable Costs are incremental costs that are incurred due to the operation of the dredge and are evaluated on an operating day basis. They include:

- Pipe Wear: Pipe used in dredging wears out due to abrasion as a function of the quantity and type of material pumped through it. Dredge pipe typically wears over many millions of cubic yards and therefore is used over many dredge projects. Dredging contactors use a variety of often complicated means to allocate the cost of pipe wear to individual projects. For the purposes of this analysis, we made a fairly simplistic assumption on the number of operating days the pipe investment would have to be

- Labor: Labor estimates are based on crew sizes for individual dredges. Labor rates assume local union rates including benefits with insurance and tax mark-ups.

- Fuel: Fuel estimates are based on the installed hp and assumed load factor of the various dredges using a fuel cost of $2.80/gal for non-road diesel.

- Rentals: It was assumed that a variety of the ancillary plant would be rented such as crew boats, tender boats, etc. These rental costs would be incurred only when the dredge is operating and would save on the cost of mobilizing ancillary plant such as small tugs between various areas of the state.

- Variable Maintenance: Variable maintenance expenses for each of the dredges analyzed are based on the CIRIA cost standards and include things like wear parts and maintenance requirements resulting from operation such as repairs and engine overhauls etc.

TABLE 4.2: DREDGE PURCHASE FEASIBILITY - DAILY OPERATING COSTS

		Small Hopper (split hull)	Medium Hopper (split hull)	Large Hopper	Small Cutter Suction (non class)	Medium Cutter Suction (under class)	Large Cutter Suction (under class)
Similar to a new build of :		GLDD Northerly Island	GLDD Sugar Island	Stuyvesant	Ross Island's No. 10	Manson's H.R. Morris	GLDD Texas
Dredge Characteristics							
Discharge Diameter	in	20	24	36	16	30	30
Dragarm Diameter	in	20	27	36	N/A	N/A	N/A
No. Arms	#	2	2	2	N/A	N/A	N/A
Hopper Size	cys	2,067	3,600	10,072	N/A	N/A	N/A
Installed Power	hp	4,010	8,435	14,684	N/A	N/A	N/A
Cutter Power	hp	N/A	N/A	N/A	201	1,500	3,000
Total Cutter Power (cutter + pumps)	hp	N/A	N/A	N/A	1,601	7,500	15,000
New Build Value (07') *	$	21,775,108	38,857,174	68,504,769	4,116,755	29,430,419	55,141,652
Pipeline Costs							
Float Hose	lf	500	500	700	500	1,500	1,500
Submerged Pipe	lf	3,000	3,000	3,000	5,000	10,000	15,000
Shore Pipe	lf	5,000	5,000	5,000	2,000	5,000	5,000
Float Hose	$/lf	$979	$1,312	$2,273	$698	$1,950	$1,950
Submerged Pipe	$/lf	$59	$85	$159	$38	$127	$127
Shore Pipe	$/lf	$56	$75	$136	$38	$117	$117
Float Hose	$	$489,573	$656,087	$1,591,360	$348,983	$2,925,471	$2,925,471
Submerged Pipe	$	$177,879	$255,525	$477,520	$188,232	$1,265,858	$1,898,787
Shore Pipe	$	$282,276	$376,368	$680,206	$75,274	$586,114	$586,114
Total Value Pipe		$949,727	$1,287,980	$2,749,087	$612,488	$4,777,444	$5,410,373
Pipe Cost per Workday	$/day	$1,266	$1,717	$3,665	$817	$6,370	$7,214

TABLE 4.2: DREDGE PURCHASE FEASIBILITY - DAILY OPERATING COSTS *(CONT.)*

		Small Hopper (split hull)	Medium Hopper (split hull)	Large Hopper	Small Cutter Suction (non class)	Medium Cutter Suction (under class)	Large Cutter Suction (under class)
Dredge Variable Costs							
men per shift	#	6	7	8	3	7	8
shifts per day †	#	2	2	2	3	3	3
cost per man-shift	$/day	$780	$780	$780	$640	$640	$640
Dredge Labor	$/day	$9,360	$10,920	$12,480	$5,760	$13,440	$15,360
Fuel Gallons per Day	gpd	1,420	2,988	5,202	851	3,985	7,970
Fuel $/Gallon	$/gal	$2.80	$2.80	$2.80	$2.80	$2.80	$2.80
Fuel Costs	$/day	$3,973	$8,357	$14,548	$2,380	$11,146	$22,292
Crew boat rental	$/day	$3,960	$3,960	$3,960	$3,960	$3,960	$3,960
tender boat rentals (manned) $/day	$/day	N/A	N/A	N/A	3500	10000	10000
derrick boat rentals (manned) $/day	$/day	N/A	N/A	N/A		8000	8000
Misc Rentals	$/day	$500	$1,000	$1,500	$1,500	$3,000	$4,000
Variable Maintenance	$/day	$9,581	$13,989	$15,619	$3,425	$13,185	$15,660
Total rentals and variable maint.		$14,041	$18,949	$21,079	$12,385	$38,145	$41,620
Total Variable Costs	$/day	$28,640	$39,943	$51,773	$21,341	$69,101	$86,486

TABLE 4.2: DREDGE PURCHASE FEASIBILITY - DAILY OPERATING COSTS *(CONT.)*

		Small Hopper (split hull)	Medium Hopper (split hull)	Large Hopper	Small Cutter Suction (non class)	Medium Cutter Suction (under class)	Large Cutter Suction (under class)
Dredge Fixed Costs							
Depreciation & Interest	$/yr	$2,100,645	$3,748,552	$6,608,655	$403,195	$2,882,415	$5,400,573
Insurance	$/yr	$108,876	$194,286	$342,524	$20,584	$147,152	$275,708
Fixed Labor / Overhead	$/yr	$750,000	$750,000	$750,000	$350,000	$500,000	$750,000
Fixed Maintenance	$/yr	$474,262	$692,435	$773,145	$133,580	$514,208	$610,749
Total Fixed Costs	$/yr	$3,433,782	$5,385,272	$8,474,324	$907,359	$4,043,776	$7,037,031
Daily Fixed Cost 80 days	$/day	$42,922	$67,316	$105,929	$11,342	$50,547	$87,963
Daily Fixed Cost 160 days	$/day	$21,461	$33,658	$52,965	$5,671	$25,274	$43,981
Daily Fixed Cost 240 days	$/day	$14,307	$22,439	$35,310	$3,781	$16,849	$29,321
Total Dredge Daily Costs							
Total Daily Cost 80 days	$/day	$71,562	$107,259	$157,702	$32,683	$119,648	$174,449
Total Daily Cost 160 days	$/day	$50,101	$73,601	$104,737	$27,012	$94,374	$130,467
Total Daily Cost 240 Days	$/day	$42,947	$62,382	$87,083	$25,122	$85,950	$115,807

Notes:

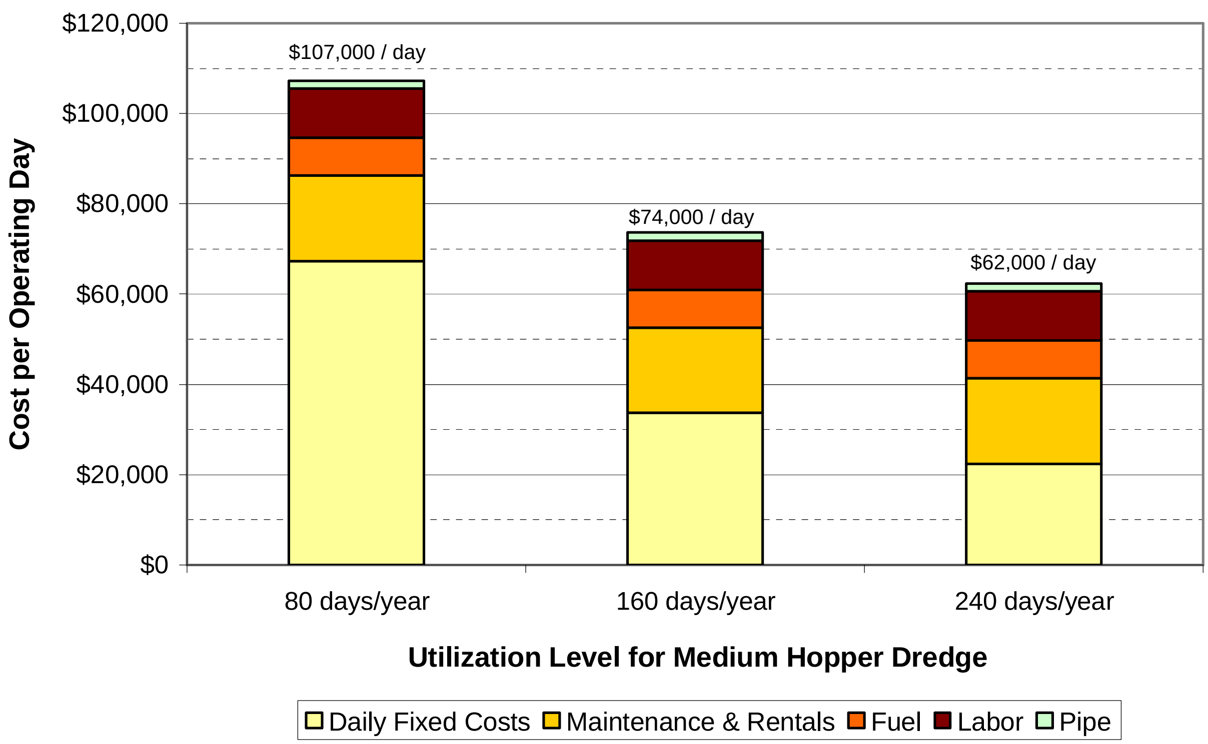
* Dredge new build value based on CIRIA formulas
† Shifts are 12-hours for hopper dredges, 8-hours for cutter suction dredges

4.4. Critical Cost Factors

4.4.1. Utilization

Fixed costs of dredge ownership are typically allocated to various projects based on operating days. For example, if one project is one third of the annual operating days of the year, that project would incur one third of the annual fixed cost of dredge ownership. Therefore, a critical element of the cost of an operating day of the dredge is the number of operating days per year the fixed cost of dredge ownership is allocated over. The graphs below demonstrate the changes in daily operating cost for the example of a medium sized hopper dredge depending on the number of days it is assumed to operate each year. When you own the dredge, this relationship between utilization and cost is true for any of the dredges evaluated. All components other than fixed cost remain constant but the total costs vary substantially with the varying levels of annual utilization.

FIGURE 4.4 IMPACT OF ANNUAL UTILIZATION ON DAILY COST: EXAMPLE



As can be seen above, the number of days of utilization has a dramatic affect on the cost of an operating day of the dredge, where the same dredge could cost $107,000 per day to operate or $62,000 per day to operate.

4.4.2. Production

Establishing the daily operating cost of the dredge is the first step in developing an estimated cost per cubic yard for beach replenishment. The second and often most variable factor driving the unit cost of dredging is the production estimate, or the average quantity of material delivered per operating day at a given borrow/receiver beach combination. Dredge production for a given dredge is driven by a number of factors, most notably the characteristics of the dredge, the material to be dredged and the distance from dig to placement site. Production estimates for various beach and receiver site combinations and resulting unit prices are detailed in the dredging scenarios section below.

4.4.3. Mobilization

Mobilization includes the costs associated with moving and setting up equipment from one project location to the next. In the case of the state owned dredge, this cost is expected to be dominated by the cost of labor and ancillary equipment rentals to move pipelines as well as the dredge labor in the period between finishing one project and starting the next. Mobilization costs are included in the analysis of dredging scenarios and are based on an assumed cost per day and number of days for interim mobilizations between beaches. An example of a pipeline installation at a receiver beach in preparation for the start of hopper dredge operations in San Diego is shown in the photo below.

FIGURE 4.5 MOBILIZATION EXAMPLE: SANDAG RBP I, PIPING INSTALLATION

4.5. Dredging Scenarios Evaluated

Estimating a unit price in $/CY of beach replenishment for comparison with contracted history requires the assumption of a scope of work for each of the six dredge purchase options evaluated. The scope of renourishment work identified in the following table was used as the basis for evaluating six dredge purchase options - small medium and large hopper and small, medium and large cutter and included 18 separate borrow/receiver site combinations as shown below.

TABLE 4.3: POTENTIAL SCOPE OF WORK EVALUATED WITH DREDGE PURCHASE ANALYSIS

Project No.	Target Reach(es)	Nourishment Project Characteristics			Borrow Location Characteristics		Derived Quantities	
		Length (LF)	Quantity (CY)	Freq. (years)	Potential Borrow Location	Transport Distance (ft)	Annualized Quantity (CY/year)	Density (CY/LF)
San Francisco Littoral Cell								
1	Ocean Beach (SF)	3,000	1,150,000	2	SF Ship Channel	34,000	575,000	383
Santa Barbara Littoral Cell								
2	Isla Vista	9,000	230,000	2	Offshore Goleta	21,000	115,000	26
3	Goleta	2,200	120,000	2	Offshore Goleta	12,000	60,000	55
4	Carpinteria Area Beaches	1,300	460,000	5	Offshore Carpinteria	7,500	92,000	354
	La Conchita							
	Oil Piers							
	Rincon Parkway							
	Pierpont							
	Emma Woods							
	San Buenaventura							
	Hobson							
5	Ventura Area Beaches (total)	18,000	1,150,000	5.00	Offshore Santa Clara	20,000	230,000	64
Santa Monica Littoral Cell								
	Escondido							
	Malibu							
	Las Tunas							
	Topanga							
	Point Dume to Topanga Canyon							

TABLE 4.4: POTENTIAL SCOPE OF WORK EVALUATED WITH DREDGE PURCHASE ANALYSIS *(CONT.)*

Project No.	Target Reach(es)	Nourishment Project Characteristics			Borrow Location Characteristics		Derived Quantities	
		Length (LF)	Quantity (CY)	Freq. (years)	Potential Borrow Location	Transport Distance (ft)	Annualized Quantity (CY/year)	Density (CY/LF)
Santa Monica Littoral Cell (continued)								
	Will Rogers Santa Monica Venice Topanga Cyn to Marina Del Rey							
	Dockweiler El Segundo Manhattan Dan Blocker Hermosa Redondo Marina Del Rey to Redondo Cyn							
6	Point Mugu to Mugu beach (feeds LA county)	165,000	6,100,000	10	Offshore Pt. Mugu	24,000	610,000	37
Oceanside Littoral Cell								
7	Oceanside	4,670	934,615	3	SO-9	23,000	311,538	200
8	N. Carlsbad Beach	3,077	500,687	3	SO-9	27,000	166,896	163
9	S. Carlsbad Beach	2,100	356,044	3	SO-7	13,500	118,681	170
10	Batiquitos Beach	1,400	262,582	3	SO-7	2,200	87,527	188
11	Leucadia Beach	2,200	289,286	3	SO-7	4,800	96,429	131
12	Moonlight Beach	800	229,203	3	SO-7	13,700	76,401	287

TABLE 4.4: POTENTIAL SCOPE OF WORK EVALUATED WITH DREDGE PURCHASE ANALYSIS *(CONT.)*

Project No.	Target Reach(es)	Nourishment Project Characteristics			Borrow Location Characteristics		Derived Quantities	
		Length (LF)	Quantity (CY)	Freq. (years)	Potential Borrow Location	Transport Distance (ft)	Annualized Quantity (CY/year)	Density (CY/LF)
Oceanside Littoral Cell (continued)								
13	Cardiff Beach	810	231,430	3	SO-6	2,800	77,143	286
14	Fletcher Cove Beach	1,900	311,538	3	SO-5	7,900	103,846	164
15	Del Mar Beach	3,227	400,549	3	SO-5	3,300	133,516	124
16	Torrey Pines Beach	1,600	534,066	3	SO-5	13,200	178,022	334
Mission Bay Littoral Cell								
17	Mission Beach / Ocean Beach (SD)	1,587	780,000	3	MB-1	4,500	260,000	491
Silver Strand Littoral Cell								
18	Silver Strand	30,000	1,160,000	3	MB-1	98,000	386,667	39
Total Nourishment Quantity			15,200,000				3,700,000	

Under each of the six dredge purchase scenarios, a cost of delivering sand from borrow site to beach for each of the eighteen beaches above was evaluated with detailed production estimates and resulting unit costs. Because all of the identified work was offshore borrow sites, the small cutter was eliminated from analysis as small cutter suction dredges are generally not classed and therefore there was no work identified that a small cutter suction dredge could perform. This leaves five dredge purchase scenarios for evaluation. In addition, some borrow / beach combinations were not feasible for certain types of dredge, in particular, the longer distance borrow site situations were sometimes beyond the capability of the cutter suction dredges (although the large cutter was capable of more beaches than the medium due to the greater horsepower available).

In each dredge purchase scenario evaluated, the given dredge was tasked with beaches from the lowest cost beach fills toward the higher cost beach fills until the dredge ran out of capacity (i.e. hit a full year of utilization) or the dredge ran out of candidate beaches it was capable of performing.

As was described in the critical cost factor discussion (Section 4.4), utilization is a key driver of the cost effectiveness of a purchased dredge. Once an investment is made in a dredge, it will be critically important that the volume of work anticipated to be performed on an annual basis actually materializes or the cost-effectiveness of the dredge will degrade with the lesser scope. Since it is likely that issues will arise with getting projects permitted and funding levels are uncertain, it is important to evaluate the cost risk of lower than the maximum scope. Therefore, within each of the five dredge purchase scenarios, we evaluated a low, medium and if enough candidate work is available, high utilization scenario, starting with the lowest unit cost beaches and working toward the more expensive work. Cost estimate details including site specific cost estimates each of these five dredge purchase scenarios are included in Appendix A. A summary of the results is discussed in the following section.

TABLE 4.4: SUMMARY OF RESULTS: FIVE DREDGE PURCHASE SCENARIOS

	Small Hopper Dredge			Small Cutter Suction Dredge		
Utilization	Low	Medium	High	Low	Medium	High
No Beaches	5	8	9	This type of dredge is not considered suitable for offshore dredging and is eliminated from consideration		
Cut Cys	572,638	1,043,319	1,653,319			
Initial Investment	$22,724,835	$22,724,835	$22,724,835			
Dredge Days	74	142	238			
Ave CY/Day	7,694	7,360	6,943			
Calendar Days	91	171	269			
Annual Fixed Costs	$3,433,782	$3,433,782	$3,433,782			
Annual Variable Costs	$3,581,305	$6,766,174	$11,011,334			
Total Annual Costs	$7,015,087	$10,199,956	$14,445,116			
$/cy Fixed Costs	$6.00	$3.29	$2.08			
$/cy variable costs	$6.25	$6.49	$6.66			
$/cy total Cost	$12.25	$9.78	$8.74			
	Medium Hopper Dredge			Medium Cutter Suction Dredge		
Utilization	Low	Medium	High	Low	Medium	High
No Beaches	8	11	14	11	All beach nourishment projects appropriate to this type of dredge are covered under the Low Utilization scenario	
Cut Cys	1,043,319	2,041,258	2,887,000	1,283,566		
Initial Investment	$40,145,154	$40,145,154	$40,145,154	34,207,863		
Dredge Days	79	166	251	83		
Ave CY/Day	13,242	12,296	11,524	15,391		
Calendar Days	108	205	307	129		
Annual Fixed Costs	$5,385,272	$5,385,272	$5,385,272	$4,043,776		
Annual Variable Costs	$4,908,973	$9,907,640	$14,884,571	$7,927,165		
Total Annual Costs	$10,294,246	$15,292,912	$20,269,843	$11,970,941		
$/cy Fixed Costs	$5.16	$2.64	$1.87	$3.15		
$/cy variable costs	$4.71	$4.85	$5.16	$6.18		
$/cy total Cost	$9.87	$7.49	$7.02	$9.33		

TABLE 4.4: SUMMARY OF RESULTS: FIVE DREDGE PURCHASE SCENARIOS *(CONT.)*

	Large Hopper Dredge			Large Cutter Suction Dredge		
Utilization	Low	Medium	High	Low	Medium	High
No Beaches	11	17	18	11	16	All beach nourishment projects appropriate to this type of dredge are covered under the Low and Medium Utilization scenarios
Cut Cys	2,041,258	3,618,667	3,678,667	1,453,566	2,717,000	
Initial Investment	$71,253,856	$71,253,856	$71,253,856	60,552,025	60,552,025	
Dredge Days	81	169	172	75	181	
Ave CY/Day	25,130	21,439	21,350	19,305	15,003	
Calendar Days	121	244	257	115	251	
Annual Fixed Costs	$8,474,324	$8,474,324	$8,474,324	$7,037,031	$7,037,031	
Annual Variable Costs	$6,210,550	$12,770,273	$13,205,385	$8,434,693	$19,779,245	
Total Annual Costs	$14,684,874	$21,244,597	$21,679,709	$15,471,723	$26,816,276	
$/cy Fixed Costs	$4.15	$2.34	$2.30	$4.84	$2.59	
$/cy variable costs	$3.04	$3.53	$3.59	$5.80	$7.28	
$/cy total Cost	$7.19	$5.87	$5.89	$10.64	$9.87	

FIGURE 4.6 DREDGE PURCHASE SCENARIOS: QUANTITY VS. UNIT COST

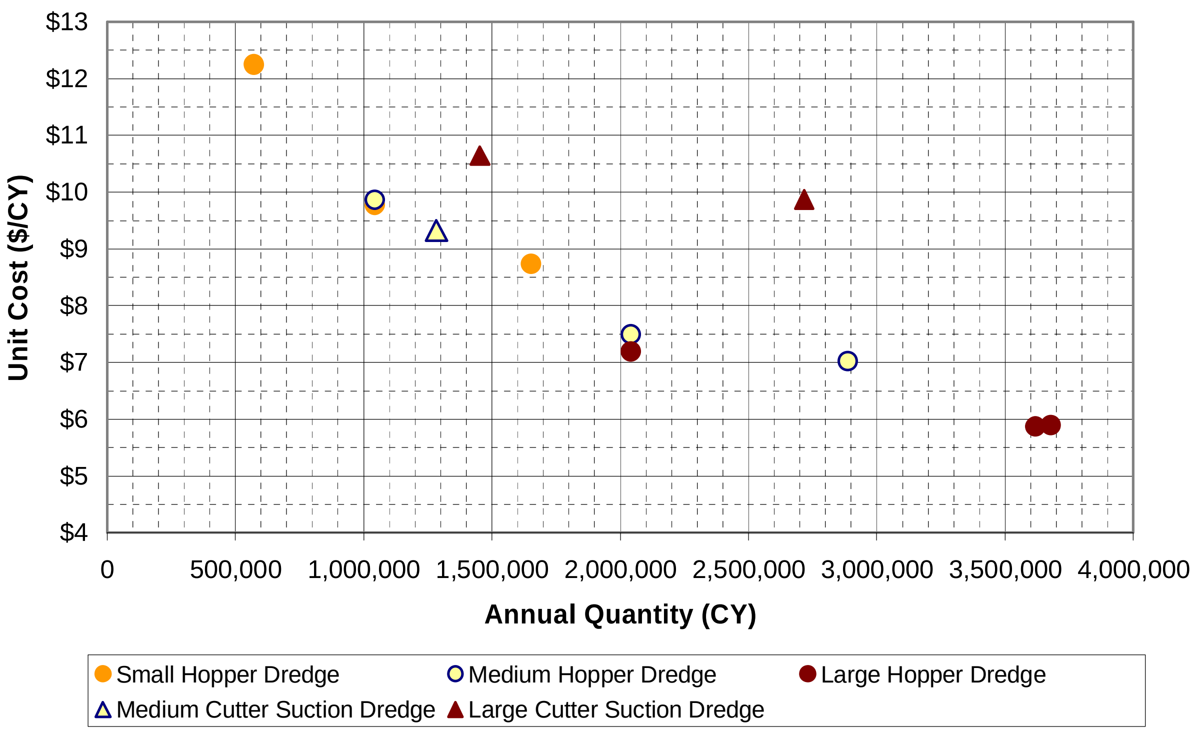


Figure 4.7 demonstrates that the larger the scope of work available, the lower the unit cost of renourishment by a state owned dredge. There are multiple points for each dredge type representing the low, medium, and high utilization cases. In the case of the large hopper, there was only one remaining candidate beach available beyond the medium utilization case so there is little difference between the medium and high utilization scenarios. The average cost for dredging in these scenarios is $8.66/cubic yard.

FIGURE 4.7 DREDGE PURCHASE SCENARIOS: EXPENDITURE VS. UNIT COST

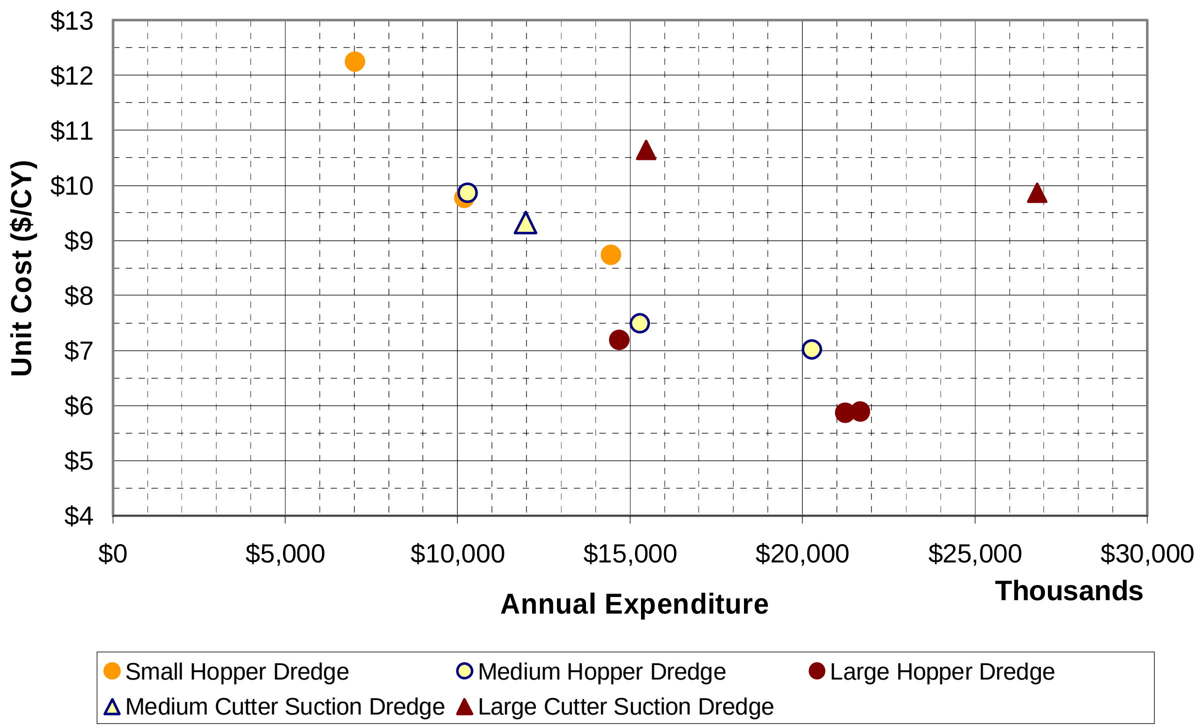
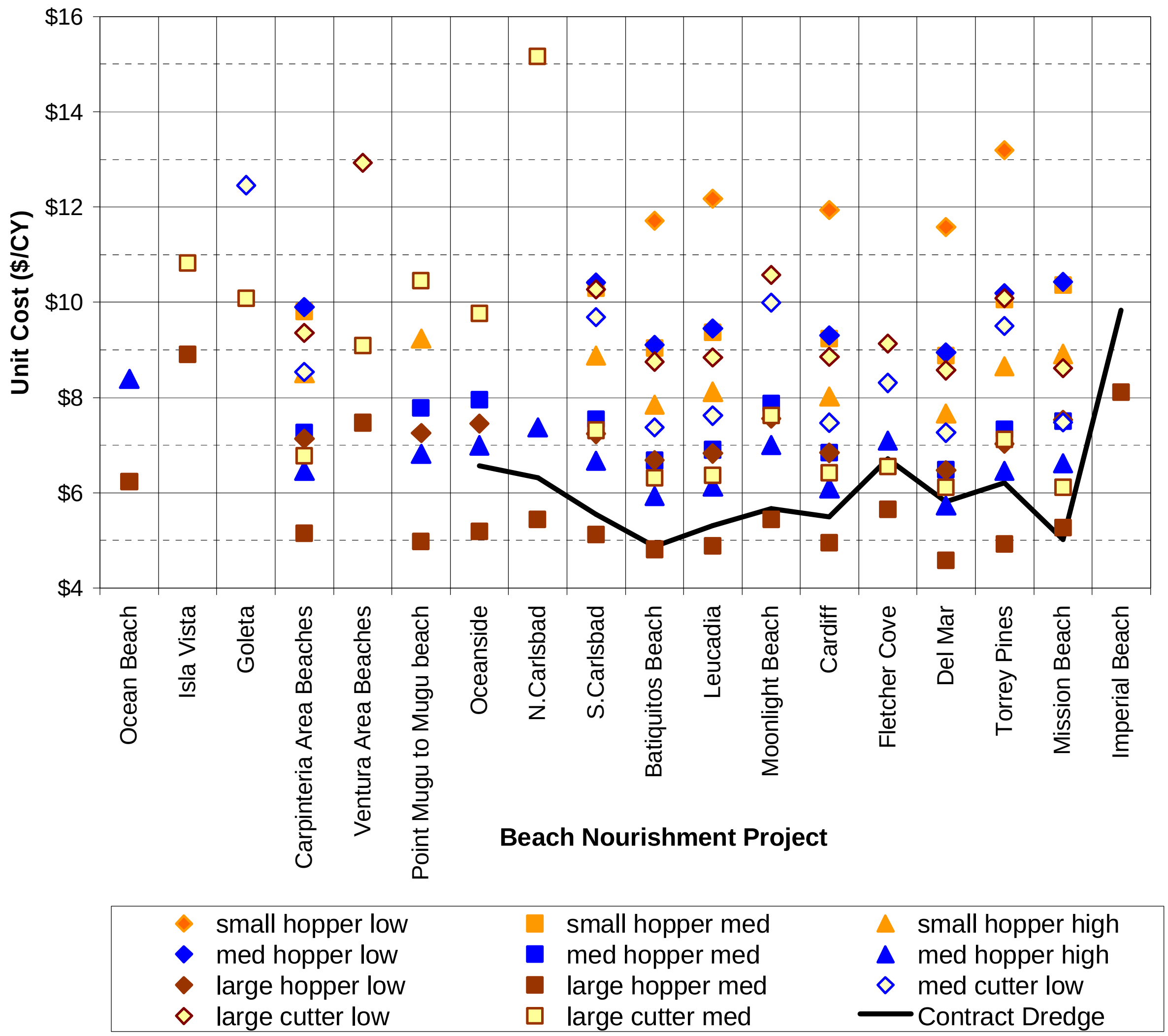


Figure 4.7 displays the level of annual funding required to operate the dredge under various dredge purchase and utilization scenarios. It indicates that a cost effective dredging program with a state owned dredge would require annual funding in excess of 15 million dollars.

4.6. Comparative Cost of Contracting Work Out

Bid history is available for individual beach replenishments from the San Diego Regional Beach Sand Project of 2001. Using ENR's construction cost index to escalate those unit prices to present day for comparison with our state dredge unit costs (1.26 escalation factor), results in the following comparison.

FIGURE 4.8 UNIT COST AT EACH BEACH VS. CONTRACTED PRICE HISTORY



In general, the analysis indicates that a state owned dredge would be less cost effective than contracted dredging in all cases except the purchase of a large hopper dredge by the state which is utilized in the medium or high utilization scenario (>3.5 mil cys per year and >$20mil per year of funding). This result builds confidence in the analysis in that it is an intuitive result (i.e. a large dredge with good utilization can compete with contract dredging but smaller dredges or dredges of low utilization can not).

The solid black line above shows the contracted unit price (escalated) for each beach with the cost of interim mobs included[2]. The dashed black line includes the $1mil plus base mob/demob of the SDRBP allocated by quantity over each beach. The average cost for contracted dredging work is $6.00/cubic yard.

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[2] The SDRBP included bid items for a base mobilization and a individual mob for each beach.

4.7. The Most Feasible Type of Dredge to Purchase

Given the scope of work identified, if the state were to purchase a dredge, the most feasible type of dredge for the state to purchase is clearly a hopper dredge. Whether or not it should be a medium or large size hopper dredge depends on available funding. However, as discussed further in this report, there are significant issues to consider before pursuing the purchase of a dredge.

4.8. Limitations of this Analysis

The largest limitations to this analysis are in regard to borrow source details, including material types and resulting production. In addition, the efficiency of operation of a state owned dredge is not at all clear. Our analysis assumes a labor force could be hired, trained, and retained to efficiently operate and maintain the dredge. In the case of a single dredge, there are likely to be inefficiencies not found in the dredge industry where core capabilities are maintained to operate fleets of dredges as compared to one. These inefficiencies of a state owned dredge are not captured in this analysis. Also, the assumptions on mobilization durations and resulting cost for the state owned dredge are very simplistic. Obviously the order in which work is performed statewide and the resources available in various parts of the state (i.e. buying separate pipe for separate regions) will have a substantial impact on mobilization costs between projects. Lastly, there is very little contracted price history upon which to base a comparison to contracted renourishment work since beach renourishment (not associated with navigation) is relatively rare in California. However, this analysis does provide for a rational evaluation of dredge types and sizes for the given scope of work. It also accurately demonstrates the key cost drivers of utilization and production. Refinements to this analysis would include making production and resulting cost adjustments for varying material types at various borrow sites. More detailed mobilization scenarios could also refine the analysis.

5. Discussion

5.1. Pros and Cons of Dredge Purchase

This section covers issues that go beyond the pure costs and benefits associated with dredge purchase and discussed in Sections 3 and 4. The following additional pros and cons have been identified.

Pros

- Purchasing a dredge prevents an individual project from having to support the long distance mobilization of an industry hopper dredge. It also may prevent time delays for projects due to the lack of available equipment.

- Purchasing a dredge will encourage beach replenishment because once the capital investment is made the incremental cost of an additional project is less than it would be to contract that project separately.

- Purchasing a dredge removes the uncertainty associated with the bid market in the dredge industry. Because a limited number of dredges exist, the timing of market demands in other parts of the country brings uncertainty in the number of bidders and bid prices for an individually contracted project.

Cons

- Purchasing a dredge capable of offshore operations is a substantial and long term investment.

- For a state owned dredge to be cost-effective, there would have to be a high confidence of being able to consistently fund, permit, and execute the volume of work necessary to justify the investment year after year for the life of the dredge. No obvious models for the State exist: see Section 5.3.1.

- Purchasing one type / size of dredge makes some individual projects less cost effective while making others more cost effective. Contracting dredging services allows for the most appropriate dredge to be applied to the project at hand.

- Allocating dredge costs between individual beaches projects and local communities would be difficult and likely contentious.

- Owing and operating a dredge exposes the state to substantial liabilities in terms of navigation mishaps, marine pollution and Jones Act injury claims (see Section 5.3.2 for more details).

- It is unclear whether the state could cost effectively staff the dredge. Issues associated with unions for the dredge crew could be very complicated for the state as there are a variety of unions with historic jurisdiction over parts of the operation and some have separate jurisdictions throughout the state (see Section 5.3.3)

- It may be more difficult for the state to operate a permanent dredge from an Air Quality permitting standpoint than multiple industry dredges operating within the state for limited periods of time each. This is because air permits for dredges are engine specific as compared to project specific. Dredges with Air Quality permits normally have an allotment of operating hours within a given air district. Therefore, having one dredge do all the work in a given district is more difficult than multiple contracted dredging projects.

5.2. Discussion of Contract Bid Market

The bid market for contracted dredging services can be highly variable depending on the type of dredge needed and the timing of the bid and performance period in question relative to the commitments of industry dredges. There has not been a steady bid market of beach replenishment work in California upon which to base an evaluation of that specific market at this time. This lack of a robust market and extensive bid history makes engineers' estimates particularly difficult and they are therefore subject to great variation from actual bid results, particularly if the specifics of the project in question are not properly appreciated. Put another way, developing engineers' estimates for work that is routinely performed, year after year with similar scope does not require a significant effort or specialized expertise. However, in situations where there is not a detailed bid history, a more detailed understanding of the drivers of contractors cost is required to generate a reliable engineer's estimate.

Nationally, hopper dredges are busy when the environmental windows in the Southeast Atlantic & Gulf coast open up (approximately November through April). The corresponding environmental window in California is approximately September through March. A well thought-out contracted replenishment program for California should evaluate the national hopper dredging market, taking advantage of periods of low demand to maximize interest and minimize bid prices.

5.3. Issues Specific to State Ownership

5.3.1. Comparison to Other Public Entities

There are other public entities that operate dredges. In all cases but the Corps, they are inshore cutter suction dredges (i.e. not classed to work offshore). The Corps does operate a fleet of dredges including offshore hopper dredges. However, this fleet is not directly comparable to a single dredge that might be purchased by the State of California. Most of the Corps dredges do not pump out. While the Corps does plan to add a pump-out capability to the Essayons, there is no history that could be directly applied to the present case.

The operation of those dredges has been the subject of congressional debate since a 1978 law was passed phasing out government hopper dredges. The cost structure for Corps operation is very complicated: however, the congress concluded that contracting dredging services is more cost effective than maintaining and operating dredges. The government has also concluded that maintaining a minimum capability of dredges is in the national interest due to the critical role the nations waterways play in national defense.

In summary, M&N has not identified any models for the state to follow where a public entity owns and operates an offshore dredge in the interest of lowering the cost or increasing the convenience of executing the work.

5.3.2. Legal Liability and Self Insurance

Owning and operating a dredge brings potential liability exposures that may not be typical for other state activities. Major insurance requirements include hull, marine pollution, and specialized worker injury insurances under the Longshoreman & Harbor workers Act (USL&H) and Merchant Marine Act (a.k.a. "Jones Act"). Many owners of large marine fleets insure through P&I clubs (i.e. a kind of international group self-insurance). The ability of the State to insure and the degree to which the state would be able to self-insure would require further research within the state government.

5.3.3. Staffing

Issues associated with unions for the dredge crew could be very complicated for the State. Politically strong unions in California that operate other types of dredges do not have clear jurisdiction over hopper dredges. They have, however, tried to claim hopper dredges in the past. For example, the San Diego Regional Beach Sand Project was involved in a claim through the State Department of Industrial Relations. There would likely be pressure on the State to require the local unions play a role if the dredge were manned through state employees. Even if the dredge were manned through a contractor, the state would be under pressure to require a union role. These issues would likely reduce the efficiency of a State owned dredge compared to a contract dredge operation.

5.4. Other Potential Uses of a State Owned Dredge

5.4.1. Leasing or Utilizing Dredge on Other Work

To the extent the state has excess capacity for its dredge (i.e. the dredge has extensive periods of being idle), costs could be defrayed by leasing the dredge or contracting dredging services. Leasing an asset like a dredge is very difficult in that they are expensive tools and documenting damage or wear beyond the norm is extremely difficult. There is also a significant opportunity for dispute in regard to the performance of the dredge relative to expectations or responsibility for breakdowns. In regard to bidding on and executing contract work, we assume that if the state began to bid on projects in competition private industry, industry objections on the fairness of competing against a state sponsored dredge would likely lead to restrictions on this activity.

5.4.2. Use of State Owned Dredge on Corps Projects

M&N discussed the use of a state owned dredge on Corps projects with Mr. George Domurat of the USACE South Pacific Division, San Francisco and Mr. Barry Holiday, Technical Director of the Dredging Contractors Association of America and former Navigation Program Manager at the USACE Headquarters in Washington D.C.

Currently, the bulk of the Corps dredging program in California is in support of their navigation mission. There are some routine O&M projects that currently place dredged material on adjacent beaches. These include projects such as Oceanside, Marina Del Rey, Ventura, Channel Islands and Port Hueneme. For a state owned dredge to participate in this work, the state would have to either compete for the work in an open bidding process (as discussed under Section 5.5, this is not likely to be a viable plan) or the state would have to have the Corps assign the work to the state owned dredge and use federal and any local sponsor funds to pay for the state executed dredging. It is not likely that this would be allowable under the Corps current procurement regulations. In addition, the transfer of the maintenance dredging responsibilities in these inlet channels to the state would likely trigger a challenging permitting scenario.

One suggestion offered by the Corps is for the state to fund additional dredging under an ongoing Corps project to get additional sand delivered to the beach. This has apparently been done on several O&M projects with local sponsor funding. While this suggestion does not provide for occupation for a state owned dredge, it would appear to be a cost effective way for state funds to accomplish beach renourishment in select locations.

The only example that could be identified where a dredge owned by a public agency (other than the Corps) was employed on federal dredge work is the dredge Oregon, owned by the Port of Portland. The Oregon reportedly maintains segments of the federal channel as well as Port berths. It is our understanding that this longstanding arrangement was achieved legislatively (i.e. literally an act of congress).

5.5. Public Financing of a State Owned Dredge

5.5.1. State Financing

As detailed in Section 4 above, if the State of California decides to purchase a dredge, a medium or large hopper dredge would make the most sense. The cost of purchasing such a dredge is estimated to be approximately $40 million for a medium sized hopper dredge and $70 million for a large hopper dredge (including pipeline costs). The most likely source of funding for such a large purchase would be from a statewide bond measure, such as the recently passed Proposition 84, which provides $5.4 billion in State funds including $540 for the protection of beaches and coastal waters. A $40 to $70 million dollar purchase would represent a substantial purchase, but given the importance of beach nourishment projects for the entire state it may be reasonable.

It is also possible that future bond issues may provide funding for such a project. The outcome of these decisions depends upon political support for nourishment in the State. $40 to $70 million is a relatively small investment for the State of California.

The variable costs would vary significantly depending upon the type of dredge used and the number of days per year the dredge is employed. The variable costs would be in the range of $3 million to $12 million per year. In April, 2000, the California Assembly passed AB 2748. Article 2.8, “The California Beach Restoration Act,” established the California Beach Restoration Program and allocated funds for beach restoration. At least some substantial portion of the variable costs could be sustained through this funding. As with any funding, the amount of funding available is subject to the political process in Sacramento, in particular competition for spending on other competing boating and waterways projects.

A number of other sources of State funding have been proposed over the years. For example, some have suggested that AB 2838, which passed in the Assembly but was subsequently vetoed by the Governor, could be used to support beach nourishment. The bill gave 20 coastal and Bay Area counties the option of increasing vehicle registration fees by up to $6 per vehicle to fund clean water and other environmental programs countywide. According to the Senate Committee on Natural Resources and Water[3]:

> "This bill would establish the Coastal Environment Motor Vehicle Mitigation account in order to fund projects that mitigate the adverse effects of motor vehicles and their related infrastructure on the coastal environment."

If all coastal counties had agreed to the maximum $6 per vehicle, it is estimated that the bill would generate $112 million per year. By no means all of these funds would be directed towards beach restoration. However, it is possible that a small portion (perhaps several million dollars) could be directed to beach restoration if it could be shown that the construction of roads, highways and bridges had contributed to beach erosion by interfering with coastal processes. Beach restoration would be the means of mitigating this. The State Coastal Conservancy is charged with running the program and presumably would establish the criteria for funding projects. It is far from clear that beach restoration would be a high priority. Further, most of the support for this bill comes from environmental groups, which have been ambivalent at best about beach nourishment projects.

Finally, many of California's beaches are State Parks. California State Parks has not been a strong proponent of beach nourishment, preferring to let the coast return to a "natural state." However, some nourishment projects, notably the 2001 SANDAG project and Surfside/Sunset (58% State Parks), have included State beaches.

5.5.2. Local Financing - General

It is likely that at least some portion of the costs would be borne by local entities—either cities or counties. Although local funding for beach nourishment projects has typically represented only a small portion of total expenses, it has often been difficult to generate the local share of project costs.

5.5.3. Transient Occupancy Taxes

In many other states, the primary source of funding for beach restoration at the local level is transient occupancy taxes (TOT's) or the equivalent, though some local authorities also use property tax assessments and the real estate transfer tax. TOT's are popular for a variety of reasons. First, they are generally paid for by non-residents[4], so that voters are less opposed when someone else is paying. Second, since TOT's are levied on tourist dollars and beaches generate tourism, there is a direct link between the tax and beach restoration.

The cities of Encinitas and Solana beach have already increased TOT's from 10% to 13% (over three years) and used two-thirds of the proceeds to create a fund to finance beach restoration.

[3] See http://info.sen.ca.gov/pub/bill/asm/ab_2801-2850/ab_2838_cfa_20060616_152145_sen_comm.html.
[4] However, an economist will point out that an increase in TOTs can also lower hotel revenues since the higher cost in TOTs will be at least partially offset by lower hotel revenues.

TOT's can generate substantial funds for beach nourishment and are generally a politically feasible way to accomplish this goal. To give an idea of how effective TOT's can be in California, we analyze the impact of a one, two, and three per cent increase in TOT's in two California beach towns which are part of this study: Carlsbad, Carpinteria. These two towns were chosen for several reasons: (1) adequate data was available from beach visitor surveys, (2) both towns have seriously considered beach nourishment as a future option, (3) these towns have not yet recently increased TOT's to fund beach nourishment.

Carlsbad

The City of Carlsbad is located in north San Diego County. It has several miles of sandy beaches, mostly run by State parks. The City's beaches benefited significantly from the 2001 SANDAG nourishment project and members of the City's Beach Preservation Committee are interested in funding future beach nourishment. The City Council has had mixed enthusiasm, partly because all of Carlsbad's shoreline is owned by the State and many Council members therefore consider beaches to be a State responsibility.

The City's total general revenue funds for 2004-5 were $187 million dollars. TOT's comprised just over $10 million dollars, or just over 5% of the total revenues. Currently, Carlsbad charges a 10% TOT. Table 5.1 estimates the increase in revenue from increasing this tax from 10% to 11%, 12%, and 13%.

TABLE 5.1: ESTIMATE OF REVENUE FROM 1%, 2% AND 3% INCREASE IN TOT: CARLSBAD[5]

Item	Increase in Revenues	Projected 5-Year Real Revenue with 2% Real Growth
Current TOT Revenues	$10,072,278	
Increase of 1%	$907,412	$4,816,655
Increase of 2%	$1,798,412	$9,547,298
Increase of 3%	$2,674,056	$14,194,213

Table 5.1 indicates that for the City of Carlsbad, raising TOT's could provide a substantial amount of revenues over a five year period (about the time periodic nourishment may be needed). Even a 1% increase would generate close to $5 million and a law similar to the neighboring cities of Encinitas and Solana Beach would generate $14 million. If only two-thirds of this were used for nourishment, as in Encinitas and Solana Beach, the City would raise $9.5 million.

[5] TOT revenues obtained from the City of Carlsbad. To calculate the increase one can not merely multiply current revenue by the proportional increase (e.g., a 10% tax generates $10 million, so a 1% increase will generate $1 million) since an increase in TOT's will also effectively lower the price hotel and condo owners can charge. Instead, we assume that the price for the hotel including TOT's remains the same in our model. This is equivalent to assuming that the supply of hotel and condo rooms is inelastic, which makes sense in the short run and, given permitting restraints, is also a reasonable assumption for the long run. Since the demand for hotel rooms is fairly inelastic (0.1 to 0.3) our results will not vary significantly if we assumed that the supply curve was inelastic, but not vertical.

It might be more realistic for the City to require only 50% be used for beach nourishment since a substantial portion of Carlsbad's TOT's (roughly 40%) are generated by two hotels – the Four Seasons and the La Costa resort – neither of which is particularly close to the beach or relies heavily on beach tourism for visitation. However, Carlsbad's TOT's are substantially higher than many other small coastal cities and hence the city would not need quite as high a tax.

Carpinteria

The City of Carpinteria is located in southern Santa Barbara County about eight miles south of Santa Barbara. It has one major beach which is divided into a City and State beach.

The city's total general revenue funds for 2004-5 were $8.4 million dollars. TOT's comprised just over $1 million dollars, or 12% of the total revenues. Currently, Carpinteria charges a 12% TOT, which is levied by Santa Barbara County but which goes to the City. Table 5.2 estimates the increase in revenue from increasing this tax from 12% to 13%, 14%, and 15%.

TABLE 5.2: ESTIMATE OF REVENUE FROM 1%, 2% AND 3% INCREASE IN TOT: CARPINTERIA

Item	Increase in Revenues	Projected 5-Year Real Revenue with 2% Real Growth
Current TOT Revenues	$1,200,000	
Increase of 1%	$88,496	$469,745
Increase of 2%	$175,439	$931,249
Increase of 3%	$260,870	$1,384,727

Table 5.2 indicates that for the City of Carpinteria, raising TOT's could provide a reasonable amount of revenues over a five year period (about the time periodic nourishment may be needed). A 3% increase would generate close to $1.4 million. If only two-thirds of this were used for nourishment, as in Encinitas and Solana Beach, the City would raise just over $900,000. While this may not be enough for a substantial nourishment project, it would go quite far as matching funds with the State.

5.5.4. Parking Fees

By law, California's beaches are open to the public and coastal access has been an important part of California's coastal policy. As a result, parking fees are sometimes discouraged, particularly by the California Coastal Commission. State Parks generally charges several dollars to park at its facilities, including its beaches. Some cities also have public parking lots that charge fees and many cities (e.g., Huntington Beach) also have metered parking. However, many beach towns charge no parking fees at all or have on-street parking which is free.

Although parking fees are unpopular, there are a number of good reasons to charge parking fees, particularly to day-trippers from out of town. Although the use of cars and parking vary by beach, a number of surveys indicate that at a typical southern California beach as many as 75% of all beach visitors get to the beach by car (most others are locals or stay at a nearby hotel or campground). Further, approximately 50% of all visitors (depending upon the beach) are day-trippers from out of town who spend very little in the town where the beach is located. Thus, using TOT's or local taxes (which are also used to support public safety at municipal beaches) essentially implies that half of all beach users at a typical southern California beach are "free-riders"—they pay virtually nothing for public safety or for beach maintenance or even for the parking spaces they occupy on city streets and parking lots. If local governments simply increase TOT's or local taxes, day trippers from out of town essentially use the beach for free. If increased parking fees are not feasible (quite possible) then it makes sense for the State of California to bear most of the non-Federal cost of nourishment,

As in the section above, this study estimates the amount of revenue that can be raised by applying a parking fee of $1 per hour. A higher (e.g., $2 hour) fee would clearly raise more revenue and may be justifiable in some circumstances. This study will again look at Carlsbad and Carpinteria. The estimates here are meant to be preliminary, not precise. Before considering whether to implement such a policy, cities are advised to do a more careful study. It should also be noted that many beaches in LA County, which are part of this study, already collect substantial revenue from parking fees.

Carlsbad

Carlsbad does not apply any parking fees on City property, though the State beaches do charge fees at some sites at South Carlsbad State beach, most notably at South Ponto beach (though a considerable amount of free parking is also available just off HWY 1). The City has several small lots at the northern end of the beach and a lot just off of Tamarack Ave.

The City also has a large amount of street parking in town and in residential areas just south of downtown. Many of these areas would work for metered parking or a system where people parking would be required to purchase a ticket ahead of time from a parking machine or from a kiosk. In residential areas, local residents would clearly need to be exempted from parking fees – this could be done at a city-wide level or by creating zones and allowing residents of the zone to park freely within the zone.

Tables 5.3 and 5.4 present our estimates of the amount of money that could be raised by levying a $1/hr parking fees in both high season (Memorial Day to Labor Day) and in low season. If the City wished, of course, it could eliminate or charge a reduced fee in low season. The tables also calculate revenues raised if locals and TOT payers are exempt. The estimates of locals and TOT payers are from a recent survey of beach-goers in Carlsbad (King, 2006).

TABLE 5.3: PARKING REVENUES IN CARLSBAD: HIGH SEASON

Item	Estimate – Everyone Pays	Estimate – Locals Exempt	Estimate – Locals and Overnighters Exempt
Number of Beach Parking Places	75	75	75
Number of Street Parking Places	600	600	600
Average Hours per Day per Place	5.5	4.8	4.3

Number of High Season Days	100	100	100
Total Hours of Paid Parking	371,250	321,131	293,288
% Locals	27%	27%	27%
% Day Trippers (not local)	42%	42%	42%
% Overnighters Staying in Carlsbad	30%	30%	30%
Total Parking Revenue at $1/hr	$371,250	$321,131	$293,288
Total Parking Fines at $30/ticket	$445,500	$385,358	$351,945
Net Parking Revenues at $1/hr	$315,563	$272,962	$249,294
Net Parking Fines at $30/ticket	$311,850	$269,750	$246,362
Net Revenue	$627,413	$542,712	$495,656

TABLE 5.4: PARKING REVENUES IN CARLSBAD: LOW SEASON

Item	Estimate – Everyone Pays	Estimate – Locals Exempt	Estimate – Locals and Overnighters Exempt
Number of Beach Parking Places	75	75	75
Number of Street Parking Places	600	600	600
Average Hours per Day per Place	1.8	1.6	1.4
Number of Low Season Days	265	265	265
Total Hours of Paid Parking	321,975	278,510	254,360
% Locals	27%	27%	27%
% Day Trippers (not local)	42%	42%	42%
% Overnighters Staying in Carlsbad	30%	30%	30%
Total Parking Revenue at $1/hr	$321,975	$278,510	$254,360
Total Parking Fines at $30/ticket	$386,370	$334,210	$305,232
Net Parking Revenues at $1/hr	$273,679	$236,732	$216,206
Net Parking Fines at $30/ticket	$270,459	$233,947	$213,662
Net Revenue	$544,138	$470,680	$429,867

A few things should be kept in mind here. First, the City will incur some administrative costs to pay for meters and enforce the fees. On the other hand, parking fines typically make up a substantial portion of parking revenues, generally close to the total amount raised by fees. The analysis here assume that 15% of parking fees will go to administration and maintenance and that 30% of parking fines will go to administration or non-payment.

Table 5.5 summarizes tables 5.3 and 5.4 above. Overall, if everyone is subject to fines and fees, the City could raise over $1,100,000 per year. If locals are exempt, the estimate drops to $1,000,000 per year and if TOT payers are also exempt, it is estimated that

$925,000 could be raised. These figures indicate that a substantial amount of money could be raised.

TABLE 5.5: PARKING REVENUES IN CARLSBAD: HIGH AND LOW SEASON

Net Revenue	Estimate – Everyone Pays	Estimate – Locals Exempt	Estimate – Locals and Overnighters Exempt
High Season Revenue	$627,413	$542,712	$495,656
Low Season Revenue	$544,138	$470,680	$429,867
Total Revenue	$1,171,551	$1,013,392	$925,523

Carpinteria

Carpinteria has a City parking lot near its main beach but does not charge for parking. Ample street parking is also available. The State beach does charge for parking. The City also has a fair amount of street parking in town. Many of these areas could be converted to metered parking or a system where people parking would be required to purchase a ticket ahead of time from a parking machine or from a kiosk. In residential areas, local residents would clearly need to be exempted from parking fees – this could be done at a city-wide level or by creating zones and allowing residents of the zone to park freely within the zone.

Tables 5.6 and 5.7 present our estimates of the amount of money that could be raised by levying a $1/hr parking fee both in high season (Memorial day to Labor day) and in low season. If the City wished, of course, it could eliminate or charge a reduced fee in low season. The tables also calculate revenues raised if locals and TOT payers are exempt. The estimates of locals and TOT payers are from a recent survey conducted of beach-goers in Carpinteria (King 2002a). We use the same assumptions about administrative fees as in the analysis of Carlsbad.

TABLE 5.6: PARKING REVENUES IN CARPINTERIA: HIGH SEASON [6]

Item	Estimate – Everyone Pays	Estimate – Locals Exempt	Estimate – Locals and Overnighters Exempt
Number of Beach Parking Places	551	551	551
Average Hours per Day per Place	4.5	4.1	3.6
Number of High Season Days	100	100	100
Total Hours of Paid Parking	247,950	226,874	195,881
% Locals	17%	17%	17%
% Day Trippers (not local)	33%	33%	33%
% Overnighters Staying in Carpinteria	50%	50%	50%
Total Parking Revenue at $1/hr	$247,950	$226,249	$235,057
Total Parking Fines at $30/ticket	$297,540	$272,249	$235,057
Net Parking Revenues at $1/hr	$210,758	$211,874	$180,881
Net Parking Fines at $30/ticket	$208,278	$190,574	$164,540
Net Revenue	$419,036	$402,449	$345,420

TABLE 5.7: PARKING REVENUES IN CARPINTERIA: LOW SEASON

Item	Estimate – Everyone Pays	Estimate – Locals Exempt	Estimate – Locals and Overnighters Exempt
Number of Beach Parking Places	551	551	551
Average Hours per day per place	1.5	1.3	1.2
Number of Low Season Days	265	265	265
Total Hours of Paid Parking	219,023	186,170	169,743
% Locals	30%	30%	30%
% Day Trippers (not local)	40%	40%	40%
% Overnighters Staying in Carpinteria	30%	30%	30%
Total Parking Revenue at $1/hr	$219,023	$186,170	$169,743
Total Parking Fines at $30/ticket	$262,827	$223,403	$203,692
Net Parking Revenues at $1/hr	$186,170	$119,920	$103,493
Net Parking Fines at $30/ticket	$183,979	$156,382	$142,583
Net Revenue	$370,149	$276,302	$246,076

Table 5.8 summarizes tables 5.6 and 5.7 above. Overall, if everyone is subject to fines and fees, the City could raise $780,000 per year. If locals are exempt, the estimate drops

[6] Matt Roberts, Director of Parks and Recreation for the City of Carpinteria provided us with information on parking.

to $506,000 per years and if TOT payers are also exempt, it is estimated that $680,000 could be raised. Thus for Carpinteria, charging for parking, particularly in its main lot, makes a huge amount of sense and would provide substantial funds for beach nourishment.

TABLE 5.8: PARKING REVENUES IN CARPINTERIA: HIGH AND LOW SEASON

Net Revenue	Estimate – Everyone Pays	Estimate – Locals Exempt	Estimate – Locals and Overnighters Exempt
High Season Revenue	$419,036	$402,449	$345,420
Low Season Revenue	$370,149	$276,302	$246,076
Total Revenue	$789,185	$678,751	$591,496

5.5.5. Property taxes

Local jurisdictions in the State of Florida and Fire Island in New York state use special assessments on property (as part of local property tax) to raise substantial funds for nourishment. In areas where the beach clearly adds value to local property and where beaches are eroding, such a tax may be feasible in California. North San Diego County would probably be the best example of an area that meets these criteria. If one follows the example of Florida, the assessment would vary depending upon the location of the property in relation to the beach.

5.5.6. Sales Tax

The State of California allows local authorities to raise a portion of the sales tax and use the proceeds for “quality of life” issues. Even a small increase at the county level could raise necessary funds for nourishment, though this solution is unlikely to be politically feasible.

For example, one proposal considered by SANDAG several years ago is a 0.25% “quality of life” increase in the sales tax rate. State law allows such funds to be used for a variety of projects to improve the quality of life in a region. For example, sports stadiums may be financed by such a measure.[7] Currently all cities and in San Diego County levy a 7.75% sales tax except for El Cajon, which levies an 8.25% tax. According to the State Board of Equalization, the County of San Diego had $45.5 billion in taxable sales in FY 2004-5. An increase in the sales tax of 0.25% translates into an increase in revenues of $113.7 million per year, more than sufficient to finance beach nourishment. These revenue have been growing by 6% a year recently, so projecting into FY 2006-7, one should expect such a tax increase to yield on the order of $127 million.

This type of increase would likely be more politically feasible if the revenues were shared for a number of purposes, perhaps coastal protection in general. Even 5-10% of these revenues would provide $6-12 million in revenues per year.

[7] Recently Sacramento proposed such an increase to finance a new stadium for its NBA team the Kings. The measure failed.

5.5.7. Summary

Although the initial costs of a dredge are not small ($40 to $70 million), the cost represents a very small portion of a State bond fund such as Proposition 84. Assuring that such funding would be available is largely a political matter. If the public can be convinced that nourishment is worthwhile and if opposition from environmental groups can be mitigated, then financing a dredge is feasible, should the State decide to do so.

Similarly, the State of California should be able to finance the ($3 to $12 million) variable costs of a dredge. However, it is likely that at least some portion of this expense will be financed by local governments. Even though the local portion is likely to be relatively small, some cities and counties will struggle to come up with the matching funds. This section has examined a couple of options for raising these funds, raising transient occupancy taxes and dedicating a portion of the increase to nourishment, as the cities of Encinitas and Solana Beach have recently done, and raising or creating parking fees. Raising TOT's is likely to be more politically feasible than increasing parking fees, though parking fees would eliminate the problem of day-trippers who live out of town and visit California's beaches—these people, who essentially free-ride off of beach services, account for about half of all beach visitors statewide.

Special Property tax assessments on property are also an option worth considering. We favor following Florida's example and varying the assessment depending upon how far the property is from the beach. This system is administratively a bit more complicated, but it is also much fairer and much more likely to be palatable to voters. A successful property tax assessment could easily pay for all nourishment expenses in a town or city.

6. Conclusions and Recommendations

6.1. Conclusions

- There is sufficient nourishment potential and demand to evaluate a dredge purchase. However, the State must commit to a greatly increased level of long term funding for any dredge ownership scenario to be viable.

- On a regional basis, there is a nourishment demand of 3.5 to 5 million cubic yards of sand per year to meet published nourishment goals. Considering that several areas have been undernourished in recent years, the immediate need is for at least 15 to 18 million cubic yards.

- Annualized economic benefits derived from recreational uses total approximately $26 million and those from storm damage reduction reach approximately $24 million, for a combined total of $50 million for annualized economic benefits.

- Total annualized economic benefits equate to approximately $11 to $12 per cubic yard of sand used for nourishment when averaged over the state.

- The sources of sand available for additional beach replenishment work in California are predominately offshore.

- Offshore dredging requires a substantial investment due to the nature of the dredge required, specific certifications needed for dredges operating offshore, and specialized training and licensing of crew.

- A hopper dredge is much more flexible and can be applied to many more of the candidate beaches because hopper dredges are capable of dealing with longer distances between borrow site and receiver beach.

- Annual fixed cost of hopper dredge ownership ranges from $3.5 to $8.5 million dollars per year depending on size. This is independent of the amount dredged and is incurred whether the dredge works or not. To achieve a reasonable cost per cubic yard, this fixed cost must be spread over a large number of cubic yards.

- Larger dredges are more productive and more cost effective than smaller dredges.

- Contract dredging requires the payment of mobilization costs but alleviates the annual fixed cost commitment.

- By packaging work appropriately, the impact of contracted equipment mobilization can be minimized.

- Various beach and borrow source combinations are best dredged by various types and sizes of dredges. The purchase of a single dredge will optimize the costs of single type of project;

however it may eliminate the possibility of completing other types of projects. Contracting allows for the most cost effective tools to be applied to each specific project.

- The average cost for dredging using a State-owned Dredge is $8.66/cubic yard based on the scenarios evaluated.

- The average cost for contracting beach nourishment dredging work is $6.00/cubic yard based on the SANDAG (SDBP1) contract history.

- To be competitive with contracted dredging prices would require a substantial annual scope of work (>3.5 million cubic yards per year) and a substantial financial commitment (>$20mil per year). This investment in a State-wide beach nourishment program is clearly justified from a cost-benefit point of view. (Benefits average $11 to $12/cubic yard, costs average $6.00 to $8.66/cubic yard.)

This analysis confirms the general belief that there is the potential to develop a regionally based State beach nourishment program that can easily demonstrate a positive cost/benefit comparison. This conclusion is independent of dredge ownership considerations, but requires a long-term financial commitment.

6.2. Recommendations Regarding Dredge Ownership vs. Contracting

After a detailed review of the relative cost of dredge ownership and consideration of the various issues associated with State ownership of a dredge, we recommend the State not pursue the purchase of a dredge for beach replenishment. The fundamental reasons for this recommendation are the expense, the complications of dredge ownership and the expectation that the private dredge industry could respond to the identified beach renourishment needs more efficiently than a state run dredge could.

The dredges required for the scope of beach replenishment identified (hopper dredges) are typically not resident in California. For this reason, there is often a significant mobilization expense for an individual beach replenishment project. In the case of the San Diego Regional Beach Project, that expense was more than $1 million dollars and in our judgment that was a relatively low number due to the fact that that dredge had just finished work in the Pacific Northwest (i.e. no Panama Canal mobilization required). Whether the mobilization is one million dollars or three million dollars, mobilization is a significant expense and spreading that mobilization over small scale quantities of beach work can make some projects cost prohibitive. However, owning a dredge is an enormous financial burden. In paying for industry dredge mobilizations, clients of dredging contractors are paying to get the right dredge when they need it and paying to release that dredge (and it's associated cost) as soon as the work is completed. With proper packaging of work and particularly if a steady volume of work can be developed, these mobilization costs can be managed and minimized as follows.

6.3. Recommendations for Improving the Cost Effectiveness of a Contracted Beach Program

This analysis and the associated cost models were developed to evaluate the feasibility of a State owned dredge. However, they also provide useful insight into the drivers of cost for contract dredging companies: the same issues of maximizing utilization and optimizing production and cost apply to industry dredges. As such, this analysis can be used to identify ways to maximize the cost effectiveness of a contracted beach renourishment program.

- Costs can be minimized in a contracted renourishment program by grouping beaches of similar scope (i.e. requiring similar dredge type) together in single contracts. This allows mobilization costs to be spread over larger quantities.

- A steady stream of funding and beach work will bring efficiencies because more frequent work will improve the likelihood of industry dredges being in the area. Should the volume of work be sufficient enough to justify the investment, the industry is capable of responding by building dredges. This is evidenced by the construction of two $50+ million dollar hopper dredges in the U.S. in the last six years.

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APPENDICES

A through C

A. Specific versus Regional Beach Replenishment Analysis

Table A.1 gives a specific list of high- and medium-priority projects identified by the Department of Boating and Waterways (Sterrett, 2007). This list is based on published project descriptions of high- and medium-priority beaches, excluding projects certain or likely to be funded by the US Army Corps of Engineers (see Section 2.2). Within each priority category, the beaches are listed in geographical order (north to south).

TABLE A.1: ILLUSTRATIVE LIST OF BEACH REPLENISHMENT PROJECTS

Location	Interval (years)	Quantity (cu.yd.)	Annual Qty (cy/yr)
Identified as High-Priority			
Ocean Beach, San Francisco	5	1,000,000	200,000
Goleta County Beach, Santa Barbara Co.	7	400,000	57,000
Encinitas-Solana Beach, San Diego Co.	5	1,500,000	300,000
Total Quantity for High-Priority Beaches:			557,000
Identified as Medium-Priority			
Crown Beach, Alameda	10	150,000	15,000
Coyote Point, San Mateo Co.	7	150,000	21,000
Isla Vista, Santa Barbara Co.	5	900,000	180,000
Refugio State Beach, Santa Barbara Co.	5	200,000	40,000
El Capitan State Beach, Santa Barbara Co.	5	200,000	40,000
Carpinteria Beach, Carpinteria	7	600,000	86,000
Hobson County Park, Ventura Co.	5	900,000	180,000
Emma Wood Co. Beach, Ventura Co.	5	700,000	140,000
San Buenaventura State Beach, Ventura Co.	7	500,000	71,000
Pierpont Beach, Ventura Co.	5	120,000	24,000
Dan Blocker Beach, Malibu, LA Co.	5	350,000	70,000
Redondo/Torrance Beaches, LA Co.	10	1,000,000	100,000
North County San Diego, Oceanside	5	1,000,000	200,000
Carlsbad State Beach, San Diego Co.	5	1,000,000	200,000
Mission Beach, San Diego Co.	7	700,000	100,000
Total Quantity for Medium-Priority Beaches:			1,467,000

Any list of this kind is controversial, in the selection of beaches to include, their prioritization, and the proposed nourishment quantity and frequency. This is far from the final word on beaches needing replenishment in California.

The point to recognize is that the total quantity of beach replenishment sand is approximately two million cubic yards per year, even if all identified high- and medium-priority projects are funded. It is unlikely that all of the medium-priority beaches would be funded.

B. Analysis of Recreational Benefits

The following outline approach to the economic analysis of the recreational benefits of beaches is discussed in more detail in King (2006).

Benefits Transfer

When no other analysis is available, economists generally use a technique referred to as *benefits transfer* (BT). BT entails comparing recreational sites with similar amenities (including natural amenities such as weather and man-made amenities such as snack bars), the availability of similar substitutes, and similar visitor populations and other socio-economic data. For example, if a typical day at Huntington Beach is worth $10 a day, a day at Newport Beach might also be worth $10 a day, whereas a day at a beach with fewer amenities (e.g., Ventura City Beach) would be lower. For BT to work properly, one must create a methodology for assessing the recreational value of a particular beach.

A more realistic approach to valuing a beach or other recreational site would be to assume that the value of each amenity is multiplicative – that is, one should rate each amenity on an appropriately defined scale and then multiply each amenity's point value to derive a final index. The index can then be translated to a day use value. This is the approach used by the Corps, for example.

This study uses a set of criteria developed by Dr. King and used for a number of State and local sponsored studies to assess the recreational value of beaches for Southern California. The following six criteria were included in the analysis:

1. *Weather*: Typically California beaches are overcast early in the morning and clear before noon, though some beaches remain overcast for a significant number of days. In assessing the weather, the number of sunny days, average temperature of the air and water, currents, and wind could all be considered. For example, Oxnard suffers from a large number of cloudy days, windy and cold weather and colder than average water temperature.

2. *Water Quality/Surf*: Water quality has become a critical issue for southern California, leading to the closing of many beaches. This factor will be revised in future studies and model updates since waves and water quality are quite different attributes, as pointed out by some reviewers.

3. *Beach Width and Quality*: Beach width is an important criterion, particularly in an examination of the use of opportunistic sediment for beach nourishment. While wider is not always better, generally people prefer wider beaches. Most beaches in southern California have good sand quality (and little cobble except near shore), so sand quality is not an important issue for this study.

4. *Overcrowding*: Previous surveys of beach goers generally indicate that overcrowded beaches are considered less desirable. Crowding can be measured in a number of ways. Typically, it is measured by the amount of sand available per person, though crowding can also occur in the water, in parking lots, snack bars, etc.

5. *Beach Facilities and Services*: Beach goers generally prefer restrooms, trashcans, and lifeguards. Most (but not all) also prefer some food facilities and other shops.

6. *Availability of Substitutes*: If similar beaches are available within a short distance, a beach is less valuable – in particular it may not make sense to nourish a beach if another similar beach is available nearby. However in making an assessment of substitutes one must keep in mind the differing preferences of beach users, e.g., some prefer a City beach with an urban ambiance while other prefer a more natural beach. One other critical issue often overlooked in studies of California beaches is congestion and availability of parking. In particular, Los Angeles, Orange County, and San Diego have plenty of beaches with similar amenities, but virtually all of these beaches are crowded on summer weekends and parking is often unavailable after noon.

The point system, shown in Table B.1, is used in the current study. Note that the system being developed is tentative and that assigning point values is always somewhat subjective. Also keep in mind that the rating will depend on what type of recreational value one is examining; for example, surfing requires a significantly different mix of recreational factors than does lying on the sand or swimming. Also, seasonality obviously plays a role in the point system; this study focuses on the high season.

TABLE B.1: RATING SYSTEM FOR BENEFITS TRANSFER

Amenity	Point Value
Weather	0 - 100%
Water Quality / Surf	0 - 100%
Beach Width and Quality	0 - 100%
Overcrowding	0 - 100%
Beach Facilities and Services	0 - 100%
Availability of Substitutes	0 - 100%

This study considers recreational values in both high and low seasons and weights the type of recreation by the percentage of users (e.g., if 14% of users are surfers, the value of this surfing is weighted accordingly).

With these limitations in mind, the following criteria were used to determine individual amenity point values for this study:

1. *Weather*: Points are assigned according to the number of warm sunny days. A perfect score of 100 would indicate that every day is warm and sunny. High winds are a negative factor. A score of 90-100 indicates almost perfect weather. Since virtually all southern California beaches have morning fog it is unlikely any California beach would score in the 90s. Some beaches where sunshine is predominant after 10 or 11 am (e.g., Huntington) should score in the 80s. Beaches with generally poor weather (e.g., Oxnard) would score below 50%.

2. *Water Quality/Surf*: Some beaches in southern California (e.g., Huntington) are closed periodically due to poor water quality. A perfect score for water quality indicates that there

are no water quality issues and no closures. Some beaches (e.g. Carpinteria) come close. Surf is a more difficult category since surfers and swimmers sometimes have diametrically opposed preferences. This report focuses on swimmer preferences with some consideration for surfers, because swimmers typically spend more time on a nourished beach than surfers.

3. *Beach Width and Quality*: For this study, the ideal beach width is approximately 100-250 ft. (e.g. Huntington). Narrower beaches are scored lower in direct proportion to width. Few beaches in California are too wide but it is possible that a beach could be so wide that access is restricted. The quality of the beach depends on the quality of the sand – a fine white sandy beach is ideal and a beach with cobble is much less desirable.

4. *Overcrowding*: The Corps often follows a policy that 100 square feet of space is necessary per person. In practice this variable is difficult to measure without a precise study. The value here also must be a composite of weekday and weekend values and, of course crowding depends on beach width and availability of parking. A score of 100 would indicate a beach where crowding is not an issue. (It does not mean "no" crowds and, of course, some beach visitors like crowds up to a point.) A low score is indicative of a beach where crowds significantly degrade the experience.

5. *Beach Facilities and Services*: This category is primarily concerned with manmade recreational amenities. Restrooms, some snack facilities and other retail, and lifeguards services all generally add to the level of amenities. While the USACE considers a wide availability of recreational opportunities to be a plus, in some cases consumers prefer a beach primarily for sunbathing. A beach with a score of 90-100 would have all the man-made amenities associated with a good quality beach (lifeguards, snack bars, close availability of retail and rental).

6. *Availability of Substitutes*: A beach would score high if there are few substitutes available nearby. If a beach has a particular set of attributes that are hard to find elsewhere, then it would score higher as well. If substitutes are available but already crowded, one must also consider this factor. As a practical matter, in Southern California there is a wide array of beaches available nearby, but most are crowded on weekends. High quality beaches which are not particularly close to other similar quality beaches (Carpinteria and San Clemente) should score higher.

The final point value assigned is also a percentage between 0 and 100. The final value is obtained conceptually as follows:

$$\text{Final Point Value} = M \times A_1 \times A_2 \times A_3 \times A_4 \times A_5 \times A_6 \qquad (1)$$

where A_i represents the amenities described above, $0 \le A_i \le 1$, and M is the maximum value of a beach day (e.g., \$14).

Creating an Index

Assigning, weighting, and multiplying amenity values must be done carefully for BT to be useful. In particular, economic theory suggests that the interaction of the amenity terms is not quite as simple as in Equation 1. For example, assume that a beach which scores 100% in all categories is worth \$14. To calculate the value of a beach which scores 50% is all six categories, apply Equation 6.1 above:

$$\text{Final Point Value} = \$14 \times A_1 \times A_2 \times A_3 \times A_4 \times A_5 \times A_6 \qquad (2)$$

$$= \$14 \times 0.5 \times 0.5 \times 0.5 \times 0.5 \times 0.5$$

$$= \$0.22$$

In other words, this methodology implies that a middling beach is worth only 22 cents per day – far too low. Economic theory suggests that the amenities should be weighted differently. In particular, the amount of satisfaction (or utility) that a consumer earns from going to the beach is a function of the amenity levels:

$$\text{Value of a Beach Day} = M \times f\,(A_1, A_2, A_3, A_4, A_5, A_6) \qquad (3)$$

A standard functional form used by economists is the Cobb-Douglas function:

$$\text{Value of a Beach Day} = M \times A_1^a \times A_2^b \times A_3^c \times A_4^d \times A_5^e \times A_6^f \qquad (4)$$

Where a + b + c + d + e + f = 1

In the equation above, each of the terms, A_i, represents the point values (in percentages from 0 to 100) from Table B.1 above. The superscripts a through f represent the relative weightings of each amenity term. If all terms are weighted equally, then each is worth 0.1667. However, some amenities may be weighted somewhat higher. To return to our previous example for a beach that scores 50% in all amenity categories, under this scheme, using Equation 4, the value of a beach day would be:

$$\text{Value of a Beach Day} = \$14 \times 0.5^{0.1667} \times 0.5^{0.1667} \times 0.5^{0.1667} \times 0.5^{0.1667} \times 0.5^{0.1667} \times 0.5^{0.1667}$$
$$= \$7 \qquad (5)$$

As expected, a beach with a rating of 50% for each amenity would receive a final value of 50% of the maximum value for a beach day of \$7.

The Cobb-Douglas function has flaws: in particular, it is difficult to establish a consumer's choices in such a way as to derive a Cobb-Douglas function. However, it is relatively tractable and incorporates the most significant elements of a utility function – the use of separate parameters for beach attributes and the law of diminishing marginal utility.

Beach Width and Overcrowding

Unfortunately, though beach replenishment is and will continue to be an important public policy issue, few detailed studies have estimated the benefits of adding sand to a beach. Since part of the purpose of this study is to assess the net benefits of beach replenishment at various beaches in California, beach width and overcrowding (amenities 3 and 4) are particularly critical to this study.

In Equation 4 above, the value of a beach day increases with the width of the beach and the amount of space each person has. If these amenities are weighted close to zero (i.e., c and d, the exponent terms for Amenities 3 and 4, are close to zero) adding more beach width has little impact on the value of a beach day. Increasing the relative weighting implies that beach width and crowding are more important to beach goers.

It also should be pointed out that this function exhibits diminishing returns: as the beach width increases, the additional value diminishes. In other words, all things equal, increasing beach width by 25 linear feet will have a greater impact on a narrow beach than on a wide beach.

Previous studies of consumer preferences (King 2001) indicate that doubling the beach width of a typical (somewhat eroded) beach in Southern California increases the value of a beach day by 15-20%, though it varies by beach. This result corresponds to a weighting of 0.15 to 0.20 for exponent c in Equation 4. Our estimates indicate that crowding is also a concern for beach goers, roughly equivalent to an exponent d weighting of 0.1 to 0.2. It should be noted, though, that these numbers are very tentative and more study is needed. Finally, it should also be pointed out that increasing beach width accomplishes two goals. The additional width is desirable, and the increased width means that more space is available on the beach, which reduces crowding; consequently doubling beach width may increase the value of a beach day by as much as 50% at a crowded narrow beach.

Nourishing a beach may also increase attendance, which increases the total recreational value, but also reduces the value per day when the beach becomes too crowded. One other factor to take into account is parking. Some beaches may be capacity constrained by limited parking (e.g., La Jolla shores beach on any summer weekend).

Suggested Weighting Scheme

Table B.2 presents a suggested weighting for each amenity for the development of this benefits model. These weights are based on empirical work and experience over the past ten years (e.g., King, 2001). These suggested weighting values do not differ dramatically from an equal weighting scheme. More empirical work will be needed in the future to refine these values. All of the categories are important because if any one category receives a rating of 0%, the recreational value is zero.

TABLE B.2: SUGGESTED WEIGHTING SCHEME FOR BENEFITS TRANSFER

Amenity	Relative Weighting
Weather	20%
Water Quality / Surf	20%
Beach Width and Quality	15%
Overcrowding	15%
Facilities and Services	15%
Availability of Substitutes	15%

Testing the Methodology for Huntington Beach

Huntington Beach's recreational value has been studied extensively. Michael Hannemann, a world renowned environmental economist, concluded that the recreational value of a lost day at Huntington Beach was worth approximately $16, in 2004 dollars (NOAA 2007). However, a more recent study, part of the *Southern California Beach Project,* using a more sophisticated model indicates that a perfect beach would score no more than $14.

TABLE B.3: APPLYING BT METHODOLOGY TO HUNTINGTON BEACH

Amenity	Amenity Point Value	Weight	Weighted Amenity Value
Weather	85%	20%	96.8%
Water Quality	75%	20%	94.4%
Beach Width and Quality	95%	15%	99.2%
Overcrowding	75%	15%	95.8%
Facilities/Services	95%	15%	99.2%
Availability of Substitutes	60%	15%	92.6%
Total Index Value		100%	79.8%
Maximum Value Per Day	$14.00		
Huntington Beach Value	$11.18		

Table B.3 applies the proposed methodology for this study to Huntington Beach. In the table, the amenity point value in the second column corresponds to the recreational value for each category. For example, Huntington Beach has been assigned a weather value of 85% since the weather in Huntington is generally good, though mornings are often overcast. On the other hand, since Huntington has had some water quality issues, a lower point value of 75% was applied. Overall Huntington scores well. Its lowest value, 60% is for availability of substitutes, reflecting the fact that many other beaches are available nearby. This report assumes that a day at a perfect beach with 100% point values would be worth $14. Huntington Beach, which offers excellent amenities, is worth $11.18. This estimate of $11.18 is consistent with other recent work by the Southern California Beach Project.

C. Analysis of Indirect Economic and Tax Revenue Impacts

In addition to the economic benefits generated by increased beach width due to nourishment, the additional attendance generated will generate additional economic activity. This is generally referred to as economic impact: that is, the additional spending that results from increased attendance. It is assumed that changes in beach width do not effect spending per person, so the only change in impact is due to increased attendance.

The increased spending at these beaches also leads to increased tax revenues.

For economic impact/tax revenue estimates, it is assumed that the primary difference in spending is due to the percentage of day tripper versus the percentage of overnight users. For each beach, an estimate of the overall composition of day trippers versus overnighters was made. When possible, survey data was used (King, 2002b). Otherwise, these estimates were made based on the best available information. Tax impact was estimated using data from the California Statistical Abstract (California Department of Finance, 2002). The values for these calculations are in Table C.1.

TABLE C.1: PARAMETERS USED IN ECONOMIC / TAX IMPACT FUNCTION

Overnight Spending per Person per Day	$55
Day Tripper Spending per Day	$16
Percentage of Spending contributed to California State Taxes	11.5%
Percentage of Local Spending contributed to Local Taxes	2.5%

This methodology is straightforward. As with other estimates in the economic analysis in this study, all estimates are on an annualized basis over a twenty year period, assuming a 5% discount rate. Table C.2 presents the results. Overall, the increase in taxes from dredging is modest. This is largely due to the fact that only increases in attendance generate new tax dollars. However, attendance at these beaches generates billions of dollars in economic activity and taxes.

TABLE C.2: ECONOMIC / TAX IMPACT BASED ON ENTIRE IDENTIFIED REPLENISHMENT NEEDS

Area	Annualized Increase in State Spending	Annualized Increase in State Taxes	Annualized Increase in Local Spending	Annualized Increase in Local Taxes
San Francisco to Ventura	$8,550,493	$983,267	$6,237,294	$213,762
Los Angeles	$5,730,790	$656,569	$4,074,400	$143,270
San Diego County	$10,195,456	$1,170,022	$7,265,578	$254,886
Total	$24,476,739	$2,809,858	$17,667,272	$611,918